

Anthony B. Costa, Ph.D.

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PERSONAL STATEMENT I am an interdisciplinary computational scientist. I have had the pleasure to work at the intersection of many fields through my scientific career, including fluid dynamics, machine learning, statistical and quantum mechanics, computational image analysis, and medical modeling. My current role is Assistant Professor of Neurosurgery at the Icahn School of Medicine at Mount Sinai and Director of Sinai BioDesign, where I lead a group of research efforts focused on improving outcomes in medicine; These include programs in machine intelligence, computational image analysis and visualization, physics-based simulation, rapid prototyping, device design, and direct patient engagement through technology.

CURRENT APPOINTMENTS **Icahn School of Medicine at Mount Sinai**, New York, NY, USA
Primary Appointment: Director, Sinai BioDesign 2017 to Present
Co-Director, Masters in Biomedical Data Science 2018 to Present
Scientific Director, Neurosurgery Simulation Core 2015 to Present
Assistant Professor, Neurosurgery 2015 to Present

- Developed Sinai BioDesign and its team from the ground up, a first-of-its-kind innovation research group focused on early stage medical device and software development, working directly with physicians and researchers to turn their needs and fledgling ideas into commercially-viable inventions.
- Developed basic and applied research tools and infrastructure for the analysis of medical imaging, together with structured and unstructured medical record data.
- Clinical- and research-facing applications include classification and segmentation of medical imaging datasets, natural language processing of medical records, surgical simulation technologies, translational medical modeling for patient engagement and surgical planning through VR, AR, and HUD platforms, and testing environments for medical device development.

Monogram Orthopaedics, New York, NY, USA
Co-Founder and Chief Science Officer 2016 to Present

- Orthopedic device startup company co-founded by Mount Sinai inventors.
- Developing next-generation computational image and geometry processing methods for the design, manufacturing, and robotically-assisted placement of novel orthopedic implants.

Numerical Solutions, Inc., Corvallis, OR, USA
Founder, President, and Chief Science Officer 2013 to Present

- Scientific and numerical consulting and research group with broad expertise in numerical and computational mathematics, engineering, physics, and chemistry.
- Work directly with partners to identify scientific questions and work to develop numerical methods and software implementations for their efficient solution.

PAST
APPOINTMENTS

Icahn School of Medicine at Mount Sinai, New York, NY, USA
Computational Scientist, Scientific Computing 2013 to 2015

- Application of high performance computing to computational genomics, structural and chemical biology, and basic clinical research and development efforts.
- Studied, designed, tested, and implemented massively parallel hardware and software resources in support of basic research on petascale data sets in life sciences research.
- Projects included performance optimization of next-generation-sequencing pipelines, molecular dynamics simulation for novel hardware architectures, and multiscale analysis and predictive modeling of unstructured clinical data.

EDUCATION

Northwestern University, Evanston, IL, USA
Postdoctoral Fellow 2010 to 2013

- Advised by Dr. Igal Szleifer.
- Department of Energy's Energy Frontier Research Center's Program.
- Non-Equilibrium Energy Research Center.
- Departments of Biomedical Engineering, Chemistry.
- Primary author of high-performance software for heterogeneous architectures used to study chaos in Hamiltonian dynamical systems. These tools provide an extensive toolkit for the study of deterministic chaos in the largest yet-simulated atomic and molecular systems.
- Software used to measure the importance of microscopic degrees of freedom during transient non-equilibrium processes. Demonstrated for the first time that a reduced statistical description of dissipation was possible by considering the dynamical entropy of the dissipative system only, without considering its surroundings.

Purdue University, West Lafayette, Indiana, USA
Ph.D., Magna Cum Laude, Chemistry 2010

- Advised by Dr. R. Graham Cooks.
- Thesis Topic: *Theory and Statistics of Ambient Mass Spectrometry*.
- Candidacy Exam: *Treanor Pumping Vibrational Transport on Hydrogen-Passivated Silicon Surfaces*.
- Developed general dimensionality reduction methods for imaging mass spectrometry applied to the determination of disease state in biological tissue. Real-time classification of tissue regions into an image giving the likelihood of cancer outperformed expert-analyzed histological staining. Method currently being applied *in vivo* during surgery.
- Identified, for the first time, a mechanism that explains the chiral selectivity and magic-number clustering of serine using a hierarchy of classical enhanced sampling methods and density functional theory. Serine clusters are implicated as one possible mechanism leading to the origin of biological homochirality.
- Used multi-phase and discrete particle computational fluid dynamics simulations to study droplet impact on surfaces and transport of progeny droplets. Demonstrated that momentum-transfer events explain the behavior of desorption-based ambient ionization methods in mass spectrometry. This mechanism is now widely accepted in the literature and used as the basis for the development of new ambient ionization methods.

- Advised by Dr. Elizabeth A. Stemmler.
- Thesis Topic: *Fragmentation of N-Terminal Derivatives of Polyalanine Peptides by Sustained Off-Resonance Irradiation Fourier Transform Mass Spectrometry.*

PUBLICATIONS

B. Marinelli, M. Kang, M. Martini, J. Zech, J. Titano, S. Cho, **A. B. Costa**, E. K. Oermann, *Combination of Active Transfer Learning and Natural Language Processing To Improve Liver Volumetry Using Surrogate Metrics with Deep Learning*, Radiology Artificial Intelligence (2019), In Press.

J. Steinberger, L. Schlachter, H. Oemke, D. Nistal, **A. B. Costa**, J. Bederson, *A Virtual Reality 360 Degree Fly-through of an Arteriovenous Malformation*, Operative Neurosurgery (2019), In Press.

D. A. Kaji, J. R. Zech, J. S. Kim, S. K. Cho, N. S. Dangayach, **A. B. Costa**, E. K. Oermann, *An attention based deep learning model of clinical events in the intensive care unit*, PLOS Biomedical Engineering (2019), In Press.

K. Yaeger, M. Martini, J. Rasouli, **A. B. Costa**, *Blockchain Technology Solutions for Modern Healthcare Infrastructure*, Journal of Scientific Innovation in Medicine, 1 (2019) 1, doi:10.29024/jsim.7.

J. J. Titano, M. Badgeley, J. Schefflein, M. Pain, A. Su, M. Cai, N. Swinburne, J. Zech, J. Kim, J. Bederson, J. Mocco, B. Drayer, J. Lehar, S. Cho, **A. B. Costa**, E. K. Oermann, *Automated deep-neural-network surveillance of cranial images for acute neurologic events*, Nature Medicine, 24 (2018) 1337-1341, doi:10.1038/s41591-018-0147-y.

A. Camara, S. Ghatan, F. Panov, **A. B. Costa**, *Robotic surgical rehearsal on patient specific 3D printed skull models for stereoelectroencephalography (SEEG)*, Int. J. CARS, (2018), doi:10.1007/s11548-018-1885-5.

J. Zech, M. A. Badgeley, M. Liu, **A. B. Costa**, J. J. Titano, E. K. Oermann, *Variable Generalization Performance of Radiological Deep Learning Models: A Cross-Sectional Study*, PLOS Medicine, 11 (2018), e1002683, doi:10.1371/journal.pmed.1002683.

J. Loewenstern, A. Aggarwal, M. Pain, E. Barthlemy, **A. B. Costa**, J. Bederson, R. K. Shrivastava, 2018, *Peritumoral Edema Relative to Meningioma Size Predicts Functional Outcomes after Resection in Older Patients*, Operative Neurosurgery, (2018), doi:10.1093/ons/opy107.

J. Zech, J. Forde, J. Titano, D. Kaji, **A. B. Costa**, E. K. Oermann, *Detecting Insertion, Substitution, and Deletion Errors in Radiology Reports Using Neural Sequence-to-Sequence Models*, Annals of Translational Medicine, (2018), doi:10.21037/21131.

J. Zech, M. Pain, J. Titano, M. Badgeley, J. Schefflein, A. Su, **A. B. Costa**, J. B. Bederson, J. Lehr, E. K. Oermann, *Natural Language Based Machine Learning Models for the Annotation of Clinical Radiology Reports*, Radiology, 287 (2018) 570-580. doi:10.1148/radiol.2018171093.

- J. Mascitelli, L. Schlachter, H. Oemke, A. G. Chartrain, J. Gillian, **A. B. Costa**, R. K. Shrivastava, J. B. Bederson, *Navigation-Linked Heads-Up Display in Intracranial Surgery: Accuracy and Utility*, Operative Neurosurgery, 15 (2018) 184-193. doi:10.1093/ons/opx205.
- R. Feng, J. Loewenstern, A. Aggarwal, P. Pawha, A. Gilani, A. M. Iloreta, R. Bakst, B. Miles, J. B. Bederson, **A. B. Costa**, V. Gupta, R. K. Shrivastava, *Cerebral Radiation Necrosis: An Analysis of Clinical and Quantitative Imaging and Volumetric Features*, World Neurosurgery, 111 (2018) 48594.
- V. Arvind, **A. B. Costa**, M. Madgeley, S. Cho, E. K. Oermann, *Wide and Deep Volumetric Residual Networks for Volumetric Image Classification*, arXiv Pre-Print, arxiv:1710.01217.
- E. K. Oermann, J. S. Multani, J. Mascitelli, K. Nicol, J. Titano, B. Skovrlj, M. Pain, J. D. Mocco, **A. B. Costa**, R. Shrivastava, *Quantitative Computed Tomography Ventriculography for Assessment and Monitoring of Hydrocephalus: A Pilot Study and Description of Method in Subarachnoid Hemorrhage*, World Neurosurgery, 104 (2017) 136-141. doi:10.1016/j.wneu.2017.04.107.
- M. Das, **A. B. Costa**, J. Green, *Extensivity and Additivity of the Kolmogorov-Sinai Entropy for Simple Fluids*, Phys. Rev. E, 92 (2017) 022102. doi:10.1103/PhysRevE.95.022102.
- S. Sarkiss, S. Philemond, J. Lee, S. Sobotka, T. D. Holloway, M. Moore, **A. B. Costa**, E. Gordon, J. B. Bederson, *Neurosurgical Skill Assessment: Measuring Technical Proficiency in Neurosurgery Residents through Intraoperative Video Evaluations*, World Neurosurgery, 89 (2016) 1-8. doi:10.1016/j.wneu.2015.12.052.
- S. Sultana, J. E. Blatt, Y. Lee, M. Ewend, J. S. Cetas, **A. B. Costa**, M. Audette, *Patient-Specific Cranial Nerve Identification Using a Discrete Deformable Contour Model for Skull Base Neurosurgery Planning and Simulation*, Lecture Notes in Computer Science, 4901 (2016) 36-44. doi:10.1007/978-3-319-31808-0_5.
- P. Kovatch, **A. B. Costa**, Z. Giles, E. Fluder, H. M. Cho, S. Mazurkova, *Big Omics Data Experience*, SC '15, 39 (2015). doi:10.1145/2807591.2807595.
- T. Holloway, Z. S. Lorsch, M. A. Chary, S. Sobotka, M. M. Moore, **A. B. Costa**, R. F. Del Maestro, J. Bederson, *Operator Experience Determines Performance in a Simulated Computer-Based Brain Tumor Resection Task*, Int. J. CARS, 10 (2015) 1853-1862. doi:10.1007/s11548-015-1160-y.
- R. G. Brook, A. Heinecke, **A. B. Costa**, P. Peltz, Jr., M. Bader, V. C. Betro, T. Baer, R. C. Hulguin, P. Dubey, *Beacon: Exploring the Application of Intel Xeon Phi Coprocessors to Scientific Computing*, Computing in Science & Engineering 17, (2015) 65-72. doi:10.1109/MCSE.2014.113.
- J. R. Green, **A. B. Costa**[‡], B. A. Grzybowski, I. Szleifer, *Relationship Between Dynamical Entropy and Energy Dissipation far from Thermodynamic Equilibrium*, PNAS, 110 (2013) 16339-16343. doi:10.1073/pnas.1312165110.

[‡]Indicates equal contribution to first author

A. B. Costa, J. R. Green, *Extending the Length and Time Scales of Gram-Schmidt Lyapunov Vector Computations*, J. Comput. Phys., 246 (2013) 113-122. doi:10.1016/j.jcp.2013.03.051.

A. L. Dill, L. S. Eberlin, **A. B. Costa**, D. R. Ifa, R. G. Cooks, *Data Quality in Tissue Analysis using Desorption Electrospray Ionization*, Anal. Bioanal. Chem., 401 (2011) 1949-1961. doi:10.1007/s00216-011-5249-z.

J. I. Zhang, **A. B. Costa**, W. A. Tao, R. G. Cooks, *Direct Detection of Fatty Acid Ethyl Esters using Low Temperature Plasma (LTP) Ambient Ionization Mass Spectrometry for Rapid Bacterial Differentiation*, Analyst, 136 (2011) 3091-3097. doi:10.1039/C0AN00940G.

A. B. Costa, R. G. Cooks, *Origin of Chiral Selectivity in Gas-Phase Serine Tetramers*, Phys. Chem. Chem. Phys., 13 (2011) 877-885. doi:10.1039/C0CP01402H.

A. L. Dill, L. S. Eberlin, **A. B. Costa**, C. Zheng, D. R. Ifa, L. Cheng, T. A. Masterson, M. O. Koch, O. Vitek, R. G. Cooks, *Multivariate Statistical Identification of Human Bladder Carcinomas using Ambient Ionization Imaging Mass Spectrometry*, Chem. A Euro. J., 17 (2011) 2897-2902. doi:10.1002/chem.201001692.

R. G. Cooks, N. E. Manicke, A. L. Dill, D. R. Ifa, L. S. Eberlin, **A. B. Costa**, H. Wang, G. Huang, Z. Ouyang, *New Ionization Methods and Miniature Mass Spectrometers in Biomedicine: DESI Imaging for Cancer Diagnostics and Paper Spray Ionization for Therapeutic Drug Monitoring*, Faraday Discuss., 149 (2011) 247-267. doi:10.1039/c005327a.

J. I. Zhang, N. Talaty, **A. B. Costa**, Y. Xia, W. A. Tao, R. Bell, J. H. Callahan, R. G. Cooks, *Rapid Direct Lipid Profiling of Bacteria using Desorption Electrospray Ionization Mass Spectrometry*, Int. J. Mass Spectrom., 301 (2011) 37-44. doi:10.1016/j.ijms.2010.06.014.

A. L. Dill, L. S. Eberlin, C. Zheng, **A. B. Costa**, D. R. Ifa, L. Cheng, T. A. Masterson, M. O. Koch, O. Vitek, R. G. Cooks, *Multivariate Statistical Differentiation of Renal Cell Carcinomas Based on Lipidomic Analysis by Ambient Ionization Imaging Mass Spectrometry*, Anal. Bioanal. Chem., 398 (2010) 2969-2978. doi:10.1007/s00216-010-4259-6.

L. S. Eberlin, A. L. Dill, **A. B. Costa**, D. R. Ifa, L. Cheng, T. Masterson, M. Koch, T. L. Ratliff, R. G. Cooks, *Cholesterol Sulfate Imaging in Human Prostate Cancer Tissue by Desorption Electrospray Ionization Mass Spectrometry*, Anal. Chem., 82 (2010) 3430-3434. doi:10.1021/ac9029482.

A. L. Dill, D. R. Ifa, N. E. Manicke, **A. B. Costa**, D. W. Knapp, R. G. Cooks, *Lipid Profiles of Canine Transitional Cell Carcinoma and Adjacent Benign Tissue by Desorption Electrospray Ionization Imaging Mass Spectrometry*, Anal. Chem., 81 (2009) 8758-8764. doi:10.1021/ac901028b.

M. Fico, J. D. Maas, S. A. Smith, **A. B. Costa**, W. J. Chappell, R. G. Cooks, *Circular Arrays of Polymer-Based Miniature Rectilinear Ion Traps*, Analyst, 134 (2009) 1338-1347. doi:10.1039/b822140e.

A. B. Costa, R. G. Cooks, *Simulated Splashes: Elucidating the Mechanism of Desorption Electrospray Ionization*, Chem. Phys. Lett., 464 (2008) 1-8. doi:10.1016/j.cplett.2008.08.020.

A. B. Costa, R. G. Cooks, *Simulation of Atmospheric Transport and Droplet-Thin Film Collisions in Desorption Electrospray Ionization*, Chem. Commun., (2007) 3915-3917. doi:10.1039/b710511h.

BOOK
CHAPTERS

A. B. Costa, *3D Printing for Medical Models: Additive Manufacturing*, in *Imaging of the Spine, 2nd Edition*, Elsevier, In Press.

K. Riley, **A. B. Costa**, J. B. Bederson, R. Shrivastava, *Cranioplasty: The Role of Cranial Implants*, in *Digital Technologies in Craniomaxillofacial Surgery*, Springer, (2017).

PATENTS

P Backeris, K. Yaeger, **A. B. Costa**, T. Oxley, A. Berenstein, Y. J. Kwon, J. Borrello, *Detachable-Tip Balloon Microcatheter for Embolization of Vascular Malformations*, Filed.

J. B. Bederson, **A. B. Costa**, P. Backeris, *Epidural/Subdural Minimally Invasive Access Tool*, Filed.

D. B. Unis, S. Somani, **A. B. Costa**, *Apparatus, Method and System for Providing Customizable Bone Implants*, Filed.

NOTABLE
EVENTS

Invited Lecturer, *How GPU Computing Can Accelerate the Treatment of Neurological Disorders*, GPU Technology Conference, San Jose, CA (2019).

Workshop Chair, *Artificial Intelligence, Advanced Digital Technologies, and Device Development in Neurosurgery*, Mount Sinai Hospital System, New York, NY (2018).

Chair, *National Center for Theoretical Sciences Health Hackathon*, Taipei, Taiwan (2018).

Visiting Professor, *National Taiwan University and National Center for Theoretical Sciences*, Taipei, Taiwan (2018).

Invited Lecturer, *Computer-Simulated Advances in Neurosurgical Research: Challenges, Successes, and Future Directions*, InCHOIR Lecturship, Icahn School of Medicine at Mount Sinai, New York, NY (2018).

Visiting Professor, *National Taiwan University, Center for Advanced Study in Theoretical Sciences*, Taipei, Taiwan (2017).

Workshop Chair, *2nd Annual SC Workshop on Medical Image Analysis and Visualization Workshop (MIAV)*, SC '17, Denver, CO (2017).

Course Director, *Advanced Use of Digital Technologies for Intracranial Surgery*, American Association of Neurological Surgeons, Los Angeles, CA (2017).

Workshop Chair, *Taking Supercomputing to the Clinic: Medical Image Analysis and Visualization*, SC '16, Salt Lake City, UT (2016).

Invited Lecturer, *Big Omics Data Experience*, SC '15, Austin, TX (2015).

Invited Lecturer, *High Field MRI for Modeling of Cranial Nerves and Small Caliber Vessels in Neurosimulation*, World Federation of Neurosurgical Societies, Rome, Italy (2015).

Invited Lecturer, *What's Next for Haptic Neurosurgery Simulators?*, European Congress of Neurosurgery, Prague, Czech Republic (2014).

Invited Lecturer, *Characterization and Benchmarking of NGS Workflow Methods on Various Platform Architectures*, Bio-IT World Conference & Expo, Boston, MA (2014).

Invited Lecturer, *Measuring Dissipation in Very-Far-From-Equilibrium Processes*, Chemistry Department Seminar Series, Bowdoin College, Brunswick, ME (2012).

Invited Lecturer, *Recent Theoretical and Experimental Results on Droplet Production and Transport in Desorption Electrospray Ionization*, Ambient Surface Analysis, Bio-Surface Interaction and Nano-Biotechnology Conference, National Physical Laboratory, Teddington, UK (2008).

CURRENT
TEACHING

Course Director and Instructor 2018 to Present
Computer Systems
Icahn School of Medicine at Mount Sinai

Course Director and Instructor 2018 to Present
Introduction to Algorithms
Icahn School of Medicine at Mount Sinai

Instructor 2016 to Present
Summer School for Computational Genomics
Community Research Education and Engagement for Data Science (CREEDS)
Icahn School of Medicine at Mount Sinai

PAST
TEACHING

Course Director and Instructor 2015 to 2018
Introduction to Scientific Computing
Icahn School of Medicine at Mount Sinai

Instructor 2013 to 2015
Introduction to Scientific Computing
Icahn School of Medicine at Mount Sinai

Teaching Assistant 2005 to 2006
Introductory Chemistry for Engineers I, II
Purdue University