Derek J. Bivona, PhD

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EDUCATION

PhD in Biomedical Engineering Aug. 2016 – Dec. 2021
University of Virginia (UVA) Charlottesville, VA
GPA: 3.96 (Relevant Coursework: Machine Learning, Soft Tissue Biomechanics)

BS in Biomedical Engineering Aug. 2012 – May 2016
Tulane University New Orleans, LA
GPA: 3.97 (Summa Cum Laude)
Relevant Coursework: Honors Linear Algebra, Mathematical Modeling of Biological Systems

RESEARCH INTERESTS

Application of data science, machine learning, and artificial intelligence to physiological systems
Growth and remodeling of soft tissues such as cardiovascular & female reproductive systems

SKILLS

Key Skills: Machine Learning, Statistical Modeling, Clustering & Classification, Dimensionality Reduction, Signal Processing, Biomechanics, Finite Element Modeling

Technical Skills: Python (with NumPy, SciPy, Pandas & Sci-Kit Learn), MATLAB, FEBio Suite (Finite Element Solver), C++, UNIX/Linux/Mac

RESEARCH

Postdoctoral Research Associate | Cardiovascular Medicine | UVA Jan. 2022 – Present
Advisor: Ken Bilchick, MD, MS

Project: Machine Learning for Multidimensional Response and Survival After Cardiac Resynchronization Therapy (CRT): Continuation of Doctoral Research

- Collaborated with an interdisciplinary team (physicians, engineers, nurses, and clinical research coordinators) to collect clinical and imaging-based parameters from 200 human patients with heart failure who received CRT (pacemaker therapy) at the UVA Health System
- Translated settings, summaries, and lead location parameters from pacemaker and defibrillator reports and echocardiography/MR images into data utilized in peer-reviewed publication
- Applied multivariate multiple linear regression to evaluate the associations among 39 clinical parameters and 3 CRT response measures
- Optimized Gaussian mixture model to stratify patients into 3 clusters, which resulted in one group with poor long-term survival, one group with intermediate survival, and another group with excellent survival
- Predicted 4-year survival using cross-validation and logistic regression with an average area under the ROC curve of 0.86 ± 0.01
- Created a web-based application (which can be accessed at http://gmmxcrt.pythonanywhere.com/ with username tester and password BilchickCRT) to allow physicians to utilize the machine learning model to identify patients who may benefit from advanced heart failure therapy
- Communicated key findings to broad audience including physicians, professors, and biotechnology companies (Medtronic & Siemens)

Graduate Research Assistant | Cardiac Biomechanics Group | UVA Aug. 2016 – Present
Advisor: Jeffrey W. Holmes, MD, PhD

Dissertation Title: "Biophysical and Statistical Modeling for Predicting the Progression and Regression of Cardiac Growth"

Project 1: A Comprehensive Finite-Element Model of Changes in Mechanics, Composition, and Growth during Post-Infarction Healing

- Constructed a biomechanics-based, finite-element (FE) model of the rat left ventricle (LV) after processing physiological signals from rat experiments
- Optimized the parameters of multiple constitutive equations based on experimental data using Monte Carlo simulations and genetic algorithms to accurately model the material behavior of both healthy and damaged cardiac tissue
- Wrote a custom material plug-in in C++ for the FEBio software to model volume loss within the FE model
- Accurately simulated the cardiac cycle while evaluating changes in LV geometry and growth due to perturbations in pressure and stiffness
- 3D models can be found at https://derekbivona.github.io/DerekBivona/ARmodels.html and seen in augmented reality [AR] on mobile devices

Project 2: Predicting Patient Response to CRT with Machine Learning

- Employed logistic regression, random forest, and support vector machine models with nested cross-validation and accurately classified patient response to CRT with an area under the ROC curve of 0.9
- Performed penalized linear discriminant analysis on cardiac strain curves (discretized functional data) derived from patient MRI and differentiated CRT responders from non-responders with 80% accuracy

Undergraduate Research Assistant Aug. 2014 – May 2016
Biomechanics of Growth and Remodeling Lab | Tulane University
Advisor: Kristin S. Miller, PhD

Experimental & Computational Approaches to Quantifying Regional Variations of Residual Strain Within the Murine Female Reproductive System

- Performed opening angle experiments on the murine female reproductive system before and after exposure to elastase
- Developed MATLAB program to analyze biaxial mechanical testing data of the murine female reproductive system
- Explored the use of a four-fiber family constitutive model (considering collagen, elastin, and smooth muscle) to describe the mechanical behavior of the murine female reproductive system

PEER-REVIEWED JOURNAL ARTICLES

1. D. Bivona, S. Tallavajhala, P. Oomen, R. Malhotra, O. Monfredi, P. Mason, S. Mazimba, M. Salerno, C. Kramer, F. Epstein, J. Holmes & K. Bilchick. "Machine Learning with Cardiac Magnetic Resonance for Multidimensional Response and Survival After Cardiac Resynchronization Therapy." Heart Rhythm O2, *In Revision*
2. D. Bivona, A. Estrada, J. Holmes & K. Yoshida. "Computational Modeling of Geometric Remodeling Following Myocardial Infarction." *Journal of Biomechanical Engineering, In Preparation*
3. D. Capone, G. Clark, D. Bivona, B. Ogola, L. Desrosiers, L. Knoepp, S. Lindsey & K. Miller. "Evaluating Residual Strain throughout the Murine Female Reproductive System." *Journal of Biomechanics, 82:299-306, 2019*

CONFERENCE PRESENTATIONS

Graduate Research

- "Cluster Analysis of Cardiac Resynchronization Response Parameters Predicts Long-Term Survival with Heart Failure" | American Heart Association Scientific Sessions (Virtual) | November 2020
- "Machine Learning vs. Medical Doctor: Predicting Patient Response to Cardiac Resynchronization Therapy Using Machine Learning" | TomTom Applied Machine Learning Conference (Oral) | April 2019
- "A Volumetric Growth Model with Unstressed Configuration Updates for Healing Post-Infarction Scar" | Summer Biomechanics, Bioengineering, and Biotransport Conference (Virtual) | June 2020
- "A Volumetric Growth Model for Healing Post-Infarction Scar" | Summer Biomechanics, Bioengineering, and Biotransport Conference (Oral) | June 2019
- "A Volumetric Growth Model for Healing Post-Infarction Scar" | NIH Interagency Modeling and Analysis Group: Multiscale Modeling Consortium Meeting (Poster) | March 2019

Undergraduate Research

- Summer Biomechanics, Bioengineering, and Biotransport Conference (Oral) | National Harbor, MD | June 2016
- Health Science and Research Day (Poster) | Tulane University School of Medicine | April 2016
- School of Science and Engineering Research Day (Poster) | Tulane University | April 2016
- Biomedical Engineering Society Annual Meeting (Oral) | Oct. 2015

AWARDS

Biomedical (Big) Data Science Training Grant Appointment July 2017 – July 2019

- Selected among all graduate students in the School of Science and Engineering to receive training in biomedical data science under an NIH funded program for two consecutive years; acted as social media chair for the program (@uva_biodatasci)

Image-Based Biomedical Modeling Summer Fellowship June 2018

- Chosen for an international program to receive training in modeling biomedical systems in Park City, Utah

National Science Foundation Graduate Research Fellowship Program – Honorable Mention April 2018

School of Science and Engineering Poster Competition, 1st Place, Tulane University April 2016

Phi Kappa Beta Honor Society, Tulane University Chapter Inducted March 2016

Tulane University Honor's Program Summer Research Grant Summer 2015

- Awarded a grant from the Honor's Program at Tulane University to conduct research on women's reproductive health

Tau Beta Pi Engineering Honor Society, Tulane University Chapter Inducted Nov. 2014

- Inducted into society for having a GPA within the top 5% of all engineering students at Tulane University; served as president

Paul M. Pope, Jr. Engineering Scholarship, Tulane University Aug. 2014 – May 2016

School of Science and Engineering Honor Society, Tulane University Inducted Aug 2013

Distinguished Scholar Scholarship, Tulane University Aug. 2012 – May 2016

Tulane University's Louisiana High School Valedictorian Scholarship Aug. 2012 – May 2016

TEACHING EXPERIENCE

Teaching Assistant | Physiology for Engineers I | UVA Jan. 2019 – May. 2019

- Created and delivered weekly lectures translating complex topics in human physiology to 65 undergraduate students
- Selected student feedback:
  1. "Derek was an amazing TA… He knows every single person's name, so when he was asked to give a presentation, he called on everyone by name. He understands the material and was great and simplifying the information for everyone..."
  2. "Derek was a wonderful TA that really aided in my understanding of the course material. He was very responsive to emails and was willing to go out of his way to meet before classes and discuss material that I didn't quite understand..."
  3. "Derek had a very relaxed and engaging teaching style that made him very approachable and helped initiate good discussions."

Teaching Assistant | Biomechanics | UVA Aug. 2018 – Dec. 2018

- Held weekly two-hour long sessions to aid 63 undergraduate students with their problem-solving skills in classic engineering subjects such as statics, dynamics, and mechanics of materials
- Developed homework and exam problem sets and provided students with solutions using a variety of multimedia sources

Guest Lecturer | BME8550 Soft Tissue Mechanics | UVA Nov. 2018

- Taught one class to graduate students about how to correctly model growth within the heart under different pathologic loading conditions
- Created in-class problems that gave the students hands on experience with calculating heart growth using an analytical slab of myocardium (heart tissue)

Grader | Biofluid Mechanics | Tulane University Aug. 2015 – Dec. 2015

- Designed and graded homework, quizzes, and exams
- Provided coursework help for students during office hours

Math and Science Tutor Aug. 2013 – May 2014
The New Orleans Charter Science and Mathematics High School | New Orleans, LA

- Tutored math and science to students from disadvantaged backgrounds

RELEVANT COURSEWORK

Undergraduate (Tulane University)
Modern Physics
Biomedical Electronics
Biomaterials & Tissue Engineering
Anatomy and Physiology with Cadaver Lab
Biomechanics
Vascular Bioengineering
Soft Tissue Biomechanics
Linear Algebra (Honors)
Mathematical Modeling of Biological Systems

Graduate (UVA)
Machine Learning
Soft Tissue Mechanics
Continuum Mechanics
Finite Element Analysis
Systems Bioengineering and Multi-Scale Modeling
Quantitative Biological Reasoning

VOLUNTEER

Baseball Buddy, Louisiana's Special Olympics Spring 2010 – Spring 2014

HOBBIES & PERSONAL INTERESTS

Baseball, iced coffee, yoga, Pixar movies, flag-football, weightlifting, ultimate frisbee