Interdisciplinary Research (IDR) Origination Awards

Cover Page

Project Title

Accurate and efficient modeling for magnetic resonance-guided focused ultrasound treatment planning

Principal Investigator(s)

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Track

Track one

Abstract

Breast cancer treatment side effects strongly impact a patient's quality of life. Magnetic resonance-guided focused ultrasound (MRgFUS) is a minimally invasive alternative to conventional breast cancer therapies that promises effective treatment with greatly reduced side effects. Though promising, MRgFUS faces challenges of prolonged, expensive, and uncomfortable treatments—which worsen side effects and can cause incomplete tumor ablation. This proposal seeks to benefit breast cancer patients by increasing the efficacy and efficiency of MRgFUS treatments through what are called model-based predictive tools. These tools can reduce procedure cost, increase the number of qualifying patients, and reduce adverse side effects.

Currently, the clinician's experience and intuition inform most decisions affecting MRgFUS treatment progression. These decisions are made in a 24-to-48-hour treatment planning window. The clinician must make many decisions regarding treatment aggressiveness, acceptable risks to healthy tissue, and equipment placement. However, clinicians are currently unable to predict within the treatment planning window many facets that are critical to success. Patients almost always suffer from impromptu delays and unexpected events.

Our team hypothesizes that computational models can improve treatment planning by augmenting the information available to the clinician. The models would predict and, in turn, avoid problems that extend the treatment and negatively impact patient outcomes. We will test this hypothesis by building an accurate, rapid simulation framework that can be executed during the treatment planning window.

Summary of Plans for External Funding

Our team will submit one internal and three external grant proposals during the award period. Each proposal will utilize results from our IDR study as preliminary data for submission. These grant proposals include:

- BYU MRI Facility seed grant. The proposal will request $8000 for MRI time that will enable an additional 40-60 subject volunteers be scanned.
- NIH National Institute of Biomedical Imaging and Bioengineering R21 Trailblazer. This opportunity allows direct costs up to $400,000 over 3 years.
- Focused Ultrasound Foundation pre-clinical award. This is a one-year award totaling approximately $100,000.
- NIH National Cancer Institute R15 Award. This three-year $300,000 award will pull together results from each of our IDR aims to reach our goal of developing a model-based treatment planning platform.

Project Narrative

I. The need for alternative breast cancer treatments

Breast cancer is the most common cancer among women worldwide and the second most common cancer overall. In the United States, it is projected that over 287,000 women will be diagnosed with new cases of invasive breast cancer in 2022, and an estimated 43,250 women in the United States will die from breast cancer [1]. While the 5-year relative survival rate for breast cancer is high (approximately 90%), breast cancer and its treatment can have a profound effect on a person's physical, emotional, and mental well-being [2–4].

Breast cancer treatment side effects strongly impact a patient's quality of life. Chemotherapy may cause fatigue, nausea, vomiting, hair loss, and cognitive impairment [5,6]. Hormonal therapy drugs can cause menopausal symptoms [5,7,8]. Surgery and radiation therapy can cause pain and soreness, with skin changes including redness, itching, and dryness [9–11]. Treatments may cause scarring and loss of sensation that can lead to body image issues, anxiety, and low self-esteem [10,12,13].

These patients can benefit from alternative, less-invasive treatments for breast cancer [14]. Magnetic resonance-guided focused ultrasound (MRgFUS) is one of these alternatives, with goals including efficacious treatment and a reduction in the physical, mental, and emotional side effects associated with current standard treatments [15–18].

II. Introduction to MRgFUS

MRgFUS is a "knifeless" technology that heats and destroys diseased tissues deep within the body precisely and noninvasively [19]. During MRgFUS, high frequency sound waves propagate from an external transducer, harmlessly pass through a coupling water bath and intervening healthy tissues and focus inside a tumor or other diseased tissue (see Figure 1). The ultrasound waves quickly increases the local tissue temperature and thermally destroy tissue in a region the size of a large grain of rice [20,21]. By repeated application to different locations, the entire tumor can be treated while minimizing damage to healthy tissues. To noninvasively monitor temperature inside the breast, the treatment is performed inside a magnetic resonance imaging (MRI) scanner [22–24].

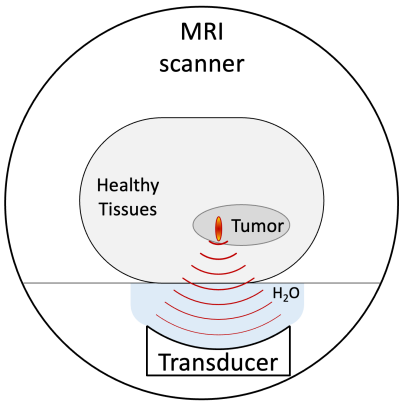

Figure 1: Schematic of MRgFUS treatment. MRgFUS can noninvasively heat and destroy diseased tissues with high precision.

Focused ultrasound's ability to non-invasively generate precise necrosis in deep tissues avoids the severe side effects of chemo- and radiation therapy. MRgFUS has no cumulative dose effects and can be repeated if necessary. Patients treated with MRgFUS can return to regular life within a few days. For breast cancer patients, MRgFUS is an especially attractive alternative for those who desire breast conserving therapy, since it is completely non-invasive and could significantly improve cosmetic outcomes [25].

III. MRgFUS treatment planning- current approach

While MRgFUS promises to destroy tumors with fewer side effects than traditional interventions, many patients experience uncomfortable, suboptimal, multi-hour treatments [26–28]. Long treatment times are not just inconvenient to the patient—they also correlate with adverse effects such as skin burns, incomplete tumor ablations, and unintended damage to surrounding healthy tissue. Reducing the duration of a given treatment improves patient outcomes, reduces cost, and increases the diversity of patients who can benefit from MRgFUS [28–31]. **This proposal seeks to address a major cause of prolonged MRgFUS treatment times: limited understanding of patient-specific treatment progression.**

The clinician uses a 24-to-48-hour pre-surgical treatment planning window to make decisions that have critical consequences for the patient. However, in current practice, the clinician relies almost entirely on previous experience and intuition to make these decisions. When the patient's anatomy and pathology extend beyond the surgeon's realm of experience, the treatment becomes suboptimal. For example, the orientation of the MRgFUS transducer relative to the patient's anatomy is critical. Bone, gas pockets, and

even large packets of adipose tissue disrupt ultrasound transmission. It is nearly impossible for a human to predict the complex ultrasound propagation patterns from the dozens to hundreds of possible applicator orientations. A misorientation, however, may introduce burns to the skin or other sensitive, healthy tissues or prevent full ablation of the target, diseased tissue. Excessive time in one orientation can lead to slow but damaging thermal exposures to healthy tissues. However, reorienting the transducer or patient takes additional time with no guarantee of improved treatment outcomes.

In short, the clinician must balance the aggressiveness of the treatment and the benefits of destroying the entire tumor against the harms of damaging healthy tissues within a complex system with many variables and degrees of freedom. Regardless of the experience of the clinician, impromptu changes to the treatment plan are universal and unexpected events almost always prolong the treatment.

IV. Model-based treatment planning- a potential solution with challenges

As an alternative to this ad hoc approach based on the clinician's intuition, model-based treatment planning would use computational models of acoustic, temperature, and tissue-damage distributions to guide patient treatments. It would include optimization of the treatment path, heating duration and power-levels that will most effectively ablate the target tumor while sparing healthy tissues. However, before model-based treatment planning for MRgFUS become a reality, the acoustic and thermal models used for computational models require improvement and extensive validation. Additionally, given the 24-to-48-hour treatment planning window, the thousands of computational scenarios necessary for treatment optimization requires a faster, streamlined modeling process that can be completed in seconds or minutes.

V. Study Hypothesis

Our team hypothesizes that model-based treatment planning can improve MRgFUS breast cancer therapies by augmenting the information available to the clinician making pretreatment planning decisions, and do so in a manner compatible with a hospital's operational workflow and financial system. These models would predict and, in turn, avoid problems that would otherwise extend the course of treatment without requiring extensive revisions to existing hospital structures. We seek to test this hypothesis by building a MRgFUS simulation framework that can be executed by a member of the surgical team within a realistic time frame and with realistic accuracy.

VI. Study Methodology

An initial investigation of the study hypothesis presented above will be performed in three specific aims to 1) improve modeling accuracy for MRgFUS treatments, 2) reduce the computational time and cost of those models, and 3) assess the appropriate product-market fit for our proposed treatment planning platform within the US healthcare system. While these aims are insufficient to fully investigate the study hypothesis, they will provide crucial preliminary data and will be the catalyst for our planned external funding proposals, in which we will extensively explore model-based treatment planning's challenges and opportunities.

Aim 1: Develop predictive models that include (a) temperature-dependent tissue properties, (b) water-content weighted property distributions, and (c) quantification of model output uncertainty based on uncertainty of model inputs. Comparison with actual treatment data from breast MRgFUS clinical trials at the University of Utah will provide evidence for model validation.

Rationale: Improved and clinically validated MRgFUS models are essential for the widespread adoption of model-based treatment planning. Unfortunately, current simulation methods consistently overpredict temperatures at the target tissue and regularly underpredict heating at other locations [32–34], in part due to the simple nature of the Pennes bioheat equation [35] and because the models do not account for temperature-dependent properties [36–38]. Thus, clinicians have limited confidence in those models. More nuanced models will improve model accuracy by better accounting for the true complexity of the biological response to acoustic heating.

Experimental Methods: The following predictive models will be evaluated using data from MRgFUS treatments of breast cancer being performed by collaborator Dr. Allison Payne at the University of Utah [39,40] using leave-one-out cross validation. **Model 1**- We will extend current models of acoustic power

deposition and the Pennes bioheat equation to account for temperature-dependent tissue properties found in the scientific literature. Thermal and acoustic properties will be dynamically updated in a finite-difference time-domain solver as local tissue temperatures change. **Model 2**- We propose to develop models with a spectrum of properties weighted by the water content of the tissue. Tissue properties based on water content are available in the literature [41] and water content can be quantified using MRI [42]. **Model 3**- This flexible Bayesian model seeks to quantify and propagate model uncertainty rather than ignore it. Using the range and anticipated distribution of each property rather than a single point estimate, the full possibilities of MRgFUS model predictions will be explored and characterized statistically.

Measures of Success: We will assess model accuracy using predictive accuracy based on leave-one-out cross validation. A model will be considered successful if it reduces prediction error relative to traditional methods by more than 1 °C.

Potential Problems and Alternative Strategies: Property values and distributions in the scientific literature may not cover all desired tissue types. Dr Dillon's research lab will identify and measure missing tissue properties using bovine samples.

Aim 2: This aim will address one of the most time-consuming portions of treatment modeling: the tissue segmentation process. We propose to reduce segmentation time by (a) developing a library of segmented breast models, (b) improving and confirming segmentation accuracy through iterative discussion and training with a clinical radiologist, and (c) using the library of segmented models to train a machine learning algorithm how to perform tissue segmentation.

Rationale: One of the most time-consuming aspects of treatment modeling is the tissue segmentation process, in which MR images are used to identify and differentiate the various tissue types required for acoustic and thermal simulations. This process of separating skin, fat, muscle, bone, tumor, etc. involves tedious often hand-determined analysis of hundreds of images (Figure 2). While software exists that semi-automates portions of the segmentation process [43], cleanup of the segmented model is still required because MR image noise, physical proximity to the imaging coils, MR sequence sensitivity and contrast, and patient motion and respiration can all confound the process.

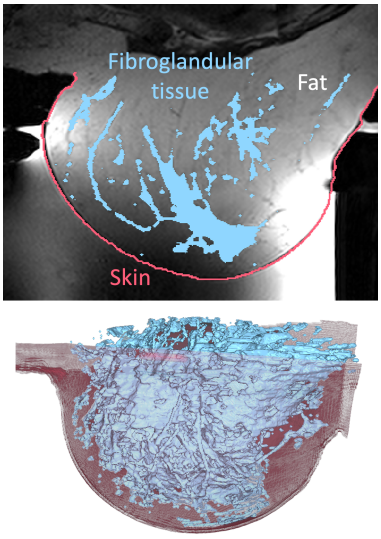

Figure 2: (Top) Single 2D image of segmented breast model overlayed on MRI scan. (Bottom) 3D projection of the segmented breast model.

Experimental Methods: **Creating the library**- The clinical MRI data described for use in Aim 1 will form the foundation of our segmentation training library. Undergraduate students will be trained to interpret the MR anatomical images, in the use of segmentation software, and in model cleanup best practices. They will segment a model for each clinical patient that can be used for Aim 1 and Aim 2. The library will be expanded by enrolling female volunteers for anatomic breast imaging for segmentation at the BYU MRI Research Facility with IRB approval. The MRI parameters used for these scans will mimic those of clinical imaging protocols. Finally, students will search publicly available imaging databases for additional datasets to include in the segmentation library. **Evaluating the library**- After a set of five anatomic segmented models have been generated, a clinical radiologist at the University of Utah will be enlisted to evaluate the accuracy of the segmentation. Training and feedback from the radiologist will be used to correct segmentation errors and to prevent similar problems in future datasets. It is anticipated that a full library of 500-1,000 segmented models will be required to complete the segmentation training library. **Training the machine learning algorithm**- 80% of the MR imaging library and corresponding segmented models will be used to train a machine learning algorithm to perform segmentation. The remaining 20% of the data will be used to validate the accuracy of the machine learning-generated segmented models. We will study the effect of convolutional neural networks (CNN's) and transformers on segmentation performance [44]. We will

evaluate our segmentation algorithm using mean intersection over union (mIoU), accuracy, precision, and recall, as is common in the literature [45].

Measures of Success: This aim will be considered successful if segmentation accuracy is at 98% or greater as evaluated by the clinical radiologist.

Potential Problems and Alternative Strategies: Modern machine learning methods (i.e., deep learning), require a large amount of labelled data. If we determine that our student-produced segmented models lack sufficient accuracy or if we cannot collect sufficient patient and volunteer data for training, we will investigate 1) data augmentation techniques to increase dataset diversity, or 2) the use of unsupervised machine learning techniques for tissue segmentation [46].

Aim 3: To assess the product-market fit for our model-based treatment planning platform, we will collect information from relevant stakeholders to identify the path of highest potential to clinical implementation. Stakeholders include current clinicians performing treatments, companies developing hardware and software for MRgFUS, fiscal intermediaries for insurance reimbursement, and staff engaged in the hospital workflow. We will identify data and visualization tools that will be most relevant and informative in developing treatments of highest efficacy and fiscal contribution.

Rationale: The introduction of new technology is complicated as interdisciplinary innovation requires participation by clinicians, researchers, vendors, facilities, and fiscal intermediaries. Currently, clinicians treat breast cancer with surgical intervention (lumpectomy, mastectomy), combined with chemotherapy, hormone therapy or radiation. Broad adoption of clinical innovations like MRgFUS combined with model-based treatment planning requires rigorous consideration by clinicians and hospital systems. It will therefore be critical to engage in discussions with current academic medical centers that offer MRgFUS in other clinical applications and evaluate their interest in enhanced treatment planning. Exploring current utilization of MRgFUS and the interest of clinicians to explore expanded treatment protocols will inform the magnitude and direction of the predictive tools we develop.

Methods: In year 2, we will determine current providers and scope of services for model-based treatment planning. We will interview clinicians and hospital staff regarding how our treatment planning results would integrate with their current workflow. By focusing specifically on breast cancer, we will identify facility Diagnosis Related Group codes (DRGs) and physician Current Procedural Terminology (CPTs) coding with their financial implications. Further, enhanced treatment planning will be explored and evaluated to determine improvements in processing time and enhanced clinical decision-making.

During year 2, we will also spend time engaging with fiscal intermediaries (Medicare, Medicaid and insurance entities) that develop comprehensive reimbursement models through facility DRG and clinician CPT coding. These efforts will improve the likelihood of our successful transition of our model-based treatment planning platform into the clinic.

Measures of Success: This aim will be considered successful when we will clearly identify what modeling data will be most useful to clinicians in the treatment planning process as well as the optimal presentation of those data.

Potential Problems and Alternative Strategies: The most appropriate stakeholders to inform our study may be difficult to identify and have minimal time for academic discussion. A key to our success may be identifying one or more clinical champions to advance our model-based treatment planning platform. Engaging with Dr. Allen's and Dr. Dillon's former and current collaborators at the University of Utah, University of Virginia, University of Michigan, Stanford University, and UCSF, and utilizing Dr. Berrett's career's worth of healthcare and hospital connections will help us realize this goal.

VII. Expected Project Outcomes

External funding proposals: Completion of these three aims will provide the team with preliminary data to pursue external grants from the NIH/NIBIB (R21 Trailblazer, $400k over three years) and NIH/NCI (R15, $300k over three years) as well as from the Focused Ultrasound Foundation (one-year $100k).

Conference presentations: This work would enable graduate and undergraduate student presentations at the 2024 Focused Ultrasound Symposium, Society for Thermal Medicine Annual Meeting (2025, 2026), Computer Vision and Pattern Recognition (2024, 2025), ISMRM 2026, ISTU 2026, and Joint Statistical Meetings 2026.

Scholarly articles (Title, Journal, Lead Author): **1**. The impact of temperature-dependent properties on predicting MRgFUS clinical responses, International Journal of Hyperthermia, Dillon. **2**. Using water-content MRI to simplify predictive modeling for MRgFUS therapies, Medical Physics, Dillon. **3**. Statistical modeling to characterize uncertainty in MRgFUS heating profiles, Annals of Applied Statistics, Dahl. **4**. Breast segmentation time-reduction with a machine-learning algorithm, Computer Vision and Pattern Recognition, Jenkins.

Student mentoring: The modeling improvements of Aim 1 will be performed by three graduate students in Dr. Dillon and Dr. Dahl's lab with assistance from 3-4 undergraduate research assistants. Aim 2 will require ten undergraduate research assistants for recruiting, imaging, and segmenting MR data under the supervision of Dr. Allen and Dr. Jenkins, with the machine-learning algorithm developed by a graduate student in the Jenkins Lab. The market fit analysis will be performed by a graduate student under the guidance of Dr. Berrett. In total, **five graduate students and at least fifteen undergraduates** will receive mentoring and research opportunities from this project.

Scientific outcomes: This study will enable the development and validation of accurate predictive models for MRgFUS therapies. The pretreatment modeling process will be shortened by the machine learning-based segmentation algorithm we create. A clear path to clinical implementation of model-based treatment planning for MRgFUS therapies will be identified. In sum, these efforts will improve patient outcomes and quality of life through more time-efficient, safer, and efficacious MRgFUS treatments for breast cancer.

VIII. Study Schedule

The study will be conducted according to the following schedule.

Study Quarter	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Aim 1								
Aim 2								
Aim 3								
Manuscript Preparation								
Proposal Preparation								

IX. Study Team

Christopher R. Dillon is a mechanical and biomedical engineer with a decade of experience in acoustic and biothermal modeling of MRgFUS therapies. He will oversee the project generally, coordinate between co-investigators at BYU and collaborators at the University of Utah, and mentor students for Aim 1. **Steven P. Allen** has a decade of experience using MRI to guide focused ultrasound surgeries, including MR sequence development, image acquisition, and image reconstruction. In this study, he will guide students in recruiting subjects and acquiring data at the BYU MRI Research Facility. **David B. Dahl** is a Bayesian statistician with extensive experience collaborating with scientists in the life sciences. He will be responsible for the statistical uncertainty modeling in Aim 1 and will also support the machine learning assessment in Aim 2 and quantitative analysis for Aim 3. **Porter Jenkins** is a computer scientist with expertise in 3D computer vision and machine learning. He will lead efforts to develop the library and machine learning algorithms for tissue segmentation described in Aim 2. **Britt Berrett** is a healthcare executive with 25+ years in academic, for-profit, not-for-profit and community-based hospitals and healthcare systems and experience introducing new clinical innovations into non-academic environments. He will oversee efforts to understand the product-market fit in Aim 3. **Allison Payne** and her team will provide de-identified MRI data for analysis from clinical breast cancer MRgFUS treatments at the University of Utah. They will provide feedback on how model-based treatment planning might be implemented clinically in Aim 3.

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Study Budget

Item	Year 1	Year 2	Total
Undergraduate Student Support (10)	**12000**	**12000**	**24000**
Graduate Student Support (3.5)	**36000**	**46000**	**82000**
MRI Scanner Usage	**8000**	**0**	**8000**
Subject Compensation	**2000**	**0**	**2000**
Supplies	**2000**	**2000**	**4000**
Total	**60000**	**60000**	**120000**

Budget Narrative

A total of **$120,000** is requested over the two-year period of this proposal. Of this amount, a total of **$82,000** is requested to support three graduate students (mentored by Drs. Dillon, Dahl, and Jenkins) who will perform, respectively, Aims 1.a - 1.b, 1.c, and 2. An additional $10,000 is budgeted in year 2 for part time support for an additional student under Dr. Berrett's supervision to conduct the market study described in Aim 3. A total of **$24,000** is requested over both years to support up to 10 undergraduate students to undertake the laborious process of segmenting MR images acquired in Aim 2, conduct subject recruitment, and acquire MR images. A total of **$8,000** is requested to support 40 MRI scans of recruited subjects plus 8 pilot scans that will be used to ensure proper data collection. Our team will pursue an MRI Research Facility Seed Grant to fund an additional $8000 of scanning to supplement the study in year 2. A total of **$2,000** is requested for subject compensation. Finally, a total of **$4,000** is requested to purchase supplies, such as tissue samples, test equipment, supercomputer time, and purchasing market research as described in Aims 1-3.

Plans for External Funding

This interdisciplinary research award will jump start efforts and provide preliminary data for multiple internal and external funding proposals described below.

In December 2023, we will pursue a **BYU MRI Facility seed grant**. The proposal will request $8000 for MRI time that will enable an additional 40-60 subject volunteers be scanned during the 2-year study period to expand our imaging library for training and evaluating the tissue segmentation machine learning algorithm.

In February of 2025, we will submit a **R21 Trailblazer proposal to the National Institute of Biomedical Imaging and Bioengineering (NIBIB) at the NIH**. This opportunity is limited to New and Early-Stage Investigators (Dr Dillon and Dr Jenkins qualify) and allows direct costs up to $400,000 over 3 years. This proposal would expand upon results from our IDR study to investigate other applications of machine learning in MRgFUS therapy treatment planning.

The team will submit a **Focused Ultrasound Foundation pre-clinical award** proposal in the Summer of 2025. This is a one-year award totaling approximately $100,000. These funds will be used to translate our machine-learning algorithm into a clinically relevant tool for segmenting breast MRI data for MRgFUS patients.

In June of 2025, we will use the preliminary data from our IDR efforts to support a **Research Enhancement Award (R15) proposal to the National Cancer Institute (NCI) at the NIH**. This three-year $300,000 award will help us pull together results from each of our IDR aims to create a model-based treatment planning platform that can be utilized for improved MRgFUS treatment planning for breast cancer. We will also work to extend the platform to other types of cancer and other diseases.

Submission of these grant proposals will follow the schedule below.

Study Quarter	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
BYU MRI Facility								
NIH/NIBIB R21								
FUS Foundation								
NIH/NCI R01								

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. DO NOT EXCEED FIVE PAGES.

NAME: Dillon, Christopher

eRA COMMONS USER NAME (credential, e.g., agency login): crdillon

POSITION TITLE: Assistant Professor

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE (if applicable)	END DATE MM/YYYY	FIELD OF STUDY
Brigham Young University, Provo, UT	BS	04/2009	Mechanical Engineering
University of Utah, Salt Lake City, UT	PHD	08/2014	Bioengineering
University of Utah, Salt Lake City, UT	Postdoctoral Fellow	12/2017	MRI-guided Focused Ultrasound

A. Personal Statement

Over the past 15 years, I have developed expertise in tissue property characterization, phase aberration correction techniques, and computational acoustic and biothermal modeling that have positioned me to successfully lead the work proposed in this study. At Sandia National Laboratories, I worked to improve the capabilities of and validate high-fidelity computational models of assembled systems in fire environments. As a NIH F32 postdoctoral fellow, I developed procedures that enabled thorough characterization of uterine fibroid tissues. In my graduate research, I developed techniques using magnetic resonance-guided focused ultrasound (MRgFUS) data to noninvasively characterize tissue thermal, blood flow, and acoustic properties.

1. Dillon C, Rezvani M, McLean H, Adelman M, Dassel M, Jarboe E, Janát-Amsbury M, Payne A. A tissue preparation to characterize uterine fibroid tissue properties for thermal therapies. Med Phys. 2019 Aug;46(8):3344-3355. PubMed Central PMCID: PMC6692230.
2. Dillon CR, Rieke V, Ghanouni P, Payne A. Thermal diffusivity and perfusion constants from in vivo MR-guided focussed ultrasound treatments: a feasibility study. Int J Hyperthermia. 2018 Jun;34(4):352-362. PubMed PMID: 28595499.
3. Dillon CR, Vyas U, Payne A, Christensen DA, Roemer RB. An analytical solution for improved HIFU SAR estimation. Phys Med Biol. 2012 Jul 21;57(14):4527-44. PubMed Central PMCID: PMC3402042.

B. Positions, Scientific Appointments and Honors

Positions and Scientific Appointments

2021 -	Assistant Professor, Brigham Young University, Mechanical Engineering, Provo, UT
2018 - 2021	R&D S&E Computer Scientist, Sandia National Laboratories, Albuquerque, NM
2014 - 2017	Postdoctoral Research Associate, University of Utah, Utah Center for Advanced Imaging Research, Salt Lake City, UT
2009 - 2014	Graduate Research Assistant, University of Utah, Bioheat Transfer Laboratory, Salt Lake City, UT
2008 - 2009	Research Assistant, Brigham Young University, Friction Stir Welding Laboratory, Provo, UT

Honors

2015 - 2017	F32 Kirschstein-NRSA Postdoctoral Fellowship, National Institutes of Health
2001 - 2007	Robert C. Byrd Honors Scholarship, Utah State Office of Education
2001 - 2007	Gordon B. Hinckley Presidential Scholarship, Brigham Young University
2001 - 2007	National Merit Scholarship, Brigham Young University
2021	Employee Recognition Award, Sandia National Laboratories
2017	Outstanding Trainee Presentation Award, 28th Annual UCAIR Symposium

2017 Higher Education Teaching Specialist, University of Utah
2014 Young Investigator Award, Focused Ultrasound Foundation
2014 New Investigator Travel Award, Society for Thermal Medicine
2008 Mechanical Engineering Department Scholarship, Brigham Young University

C. Contribution to Science

1. The Hybrid Angular Spectrum (HAS) Method for acoustic modeling will feed into the biothermal models to be developed in this study. As a postdoctoral fellow, I contributed to the validation of the HAS method in both simulation and experimental work. Additionally, I utilized HAS in studies evaluating how applying phase aberration correction techniques might improve accuracy and efficiency in MRgFUS therapies. Finally, I assisted in developing a conformable skin-cooling system for MRgFUS treatments that is now in clinical use at Stanford University. Each of these efforts has strengthened my understanding of the computational, experimental, and clinical challenges associated with the proposed work and poised me to successfully address those challenges.

    a. Merrill R, Odéen H, Dillon C, Bitton R, Ghanouni P, Payne A. Design and evaluation of an open-source, conformable skin-cooling system for body magnetic resonance guided focused ultrasound treatments. Int J Hyperthermia. 2021;38(1):679-690. PubMed Central PMCID: PMC8925859.
    b. Johnson SL, Christensen DA, Dillon CR, Payne A. Validation of hybrid angular spectrum acoustic and thermal modelling in phantoms. Int J Hyperthermia. 2018;35(1):578-590. PubMed Central PMCID: PMC6365205.
    c. Dillon CR, Farrer A, McLean H, Almquist S, Christensen D, Payne A. Experimental assessment of phase aberration correction for breast MRgFUS therapy. Int J Hyperthermia. 2018 Sep;34(6):731-743. PubMed PMID: 29278946.
    d. Farrer AI, Almquist S, Dillon CR, Neumayer LA, Parker DL, Christensen DA, Payne A. Phase aberration simulation study of MRgFUS breast treatments. Med Phys. 2016 Mar;43(3):1374-84. PubMed Central PMCID: PMC4769272.

2. In my graduate work, I developed a technique to non-invasively quantify tissue acoustic and thermal properties using magnetic resonance-guided focused ultrasound (MRgFUS) temperature data. The method improved estimates of acoustic specific absorption rate (SAR) by up to 90%. I also established appropriate MR sampling characteristics to robustly apply the method and demonstrated accuracy and improved precision of thermal diffusivity measurements. I applied these methods to determine properties directly from clinical MRgFUS data from Stanford University and UCSF. These accurate non-invasive methods provide realistic patient-specific tissue property values to inform thermal models utilized in treatment planning of MRgFUS thermal therapies.

    a. Dillon CR, Borasi G, Payne A. Analytical estimation of ultrasound properties, thermal diffusivity, and perfusion using magnetic resonance-guided focused ultrasound temperature data. Phys Med Biol. 2016 Jan 21;61(2):923-36. PubMed Central PMCID: PMC4879616.
    b. Dillon CR, Payne A, Christensen DA, Roemer RB. The accuracy and precision of two non-invasive, magnetic resonance-guided focused ultrasound-based thermal diffusivity estimation methods. Int J Hyperthermia. 2014 Sep;30(6):362-71. PubMed Central PMCID: PMC4878146.
    c. Dillon CR, Todd N, Payne A, Parker DL, Christensen DA, Roemer RB. Effects of MRTI sampling characteristics on estimation of HIFU SAR and tissue thermal diffusivity. Phys Med Biol. 2013 Oct 21;58(20):7291-307. PubMed Central PMCID: PMC3864578.

Current and Pending Support

Christopher R. Dillon

Project/Proposal Title: BYU/SNL Reduced Order Methods Collaboration
Status of Support: Active
Proposal Award Number: PO 2363288
Source of Support: Sandia National Laboratories
Primary Place of Performance: Brigham Young University
Start Date: 04/2022
End Date: 12/2023
Total Award Amount: $64,993 (Includes indirect costs)
Time commitment (Person Months): 0.75 months

Project/Proposal Title: Using imaging to understand Achilles tendon adaptation and injury in female athletes
Status of Support: Active
Source of Support: BYU Interdisciplinary Research Award
Primary Place of Performance: Brigham Young University
Start Date: 06/2022
End Date: 05/2024
Total Award Amount: $120,000 (~$4,000 for ME EN student support)
Time commitment (Person Months): 0.25 months

In Kind Contribution: New Faculty Start-up Funds
Status of Support: Active
Source of Support: Brigham Young University
Primary Place of Performance: Brigham Young University
Start Date: 11/2021
End Date: 12/2024
Summary: Student Wages $60,000; $20,000/year for three years
Capital Equipment: $180,000
PhD Stipend: $8,000
Tuition: $18,000; $6,000/year for three years
Total Award Amount: $266,000

Project/Proposal Title: Investigating the impact of subcutaneous fat properties on focused ultrasound thermal therapy outcomes
Status of Support: Pending
Source of Support: NIH/NIBIB
Primary Place of Performance: Brigham Young University
Start Date: 06/2023
End Date: 05/2026
Total Award Amount: $ 593,198 (Includes indirect costs)
Time commitment (Person Months): 3.00 months per year

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. DO NOT EXCEED FIVE PAGES.

NAME: Allen, Steven

eRA COMMONS USER NAME (credential, e.g., agency login): steven.p.allen

POSITION TITLE: Assistant Research Professor

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE (if applicable)	END DATE MM/YYYY	FIELD OF STUDY
Brigham Young University, Provo, UT	BS	04/2010	Physics
University of Michigan, Ann Arbor, MI	MS	09/2012	Biomedical Engineering
University of Michigan, Ann Arbor, Michigan	PHD	08/2015	Biomedical Engineering

A. Personal Statement

I have almost a decade's worth of experience using magnetic resonance imaging (MRI) to guide and inform focused ultrasound surgeries, including MR physics, MR sequence development and image acquisition, and image Reconstruction for focused ultrasound applications. My specialties include MR thermometry, MRI detection of cavitation, MR diffusion imaging to monitor thermal ablations, and MR-based detection and analysis of histotripsy lesions. I have been fortunate to obtain both education and research opportunities that allow me to understand the physics, engineering, and medical constraints of the proposed work.

1. Allen SP, Steeves T, Fergusson A, Moore D, Davis RM, Vlaisialjevich E, Meyer CH. Novel acoustic coupling bath using magnetite nanoparticles for MR-guided transcranial focused ultrasound surgery. Med Phys. 2019 Dec;46(12):5444-5453. PubMed Central PMCID: PMC6899167.
2. Sukovich JR, Cain CA, Pandey AS, Chaudhary N, Camelo-Piragua S, Allen SP, Hall TL, Snell J, Xu Z, Cannata JM, Teofilovic D, Bertolina JA, Kassell N, Xu Z. In vivo histotripsy brain treatment. J Neurosurg. 2018 Oct 1; PubMed Central PMCID: PMC6925659.
3. Allen SP, Vlaisavljevich E, Shi J, Hernandez-Garcia L, Cain CA, Xu Z, Hall TL. The response of MRI contrast parameters in in vitro tissues and tissue mimicking phantoms to fractionation by histotripsy. Phys Med Biol. 2017 Aug 18;62(17):7167-7180. PubMed PMID: 28741596.
4. Allen SP, Hall TL, Cain CA, Hernandez-Garcia L. Controlling cavitation-based image contrast in focused ultrasound histotripsy surgery. Magn Reson Med. 2015 Jan;73(1):204-13. PubMed PMID: 24469922.

B. Positions, Scientific Appointments and Honors

Positions and Scientific Appointments

2020 -	Assistant Research Professor, Electrical and Computer Engineering, Brigham Young University, Provo, UT
2019 - 2020	Postdoctoral Research Associate, University of Virginia, Department of Biomedical Engineering, Charlottesville,, VA
2017 - 2019	Robert M. Berne Cardiovascular Research Training Grant Fellow, Cardiovascular Research Center, University of Virginia
2015 - 2016	Postdoctoral Research Scientist, Department of Biomedical Engineering, University of Virgina

Honors

2017 - 2019	Training Fellowship, Robert M Berne Cardiovascular Research Center
2015	Postdoctoral Teaching Fellowship, University of Virginia School of Engineering
2015	Summer Research Fellowship, University of Michigan Rackham Graduate School

C. Contribution to Science

1. My early graduate publications focused on using Magnetic Resonance Imaging (MRI) to detect and monitor focused ultrasound histotripsy surgeries. MR monitoring of histotripsy surgeries present a unique challenge relative to monitoring thermal ablations because the the histotripsy ablation mechanism is non thermal and relies the the sub millisecond behavior of a cavitating bubble cloud. I developed an MR image acquisition method that can be sensitized to the activity of these bubble clouds, providing rapid and accurate monitoring of the treatment process.

    a. Allen SP, Hernandez-Garcia L, Cain CA, Hall TL. MR-based detection of individual histotripsy bubble clouds formed in tissues and phantoms. Magn Reson Med. 2016 Nov;76(5):1486-1493. PubMed PMID: 26599823.
    b. Allen SP, Hall TL, Cain CA, Hernandez-Garcia L. Controlling cavitation-based image contrast in focused ultrasound histotripsy surgery. Magn Reson Med. 2015 Jan;73(1):204-13. PubMed PMID: 24469922.

2. In addition to monitoring histotripsy bubble clouds, I was also able to develop MR imaging methods that can identify and analyze histotripsy lesions in tissues. The work involved both MR imaging development as well as tissue histology and cell microscopy work. I was able to show that different MR image contrast parameters, such is the apparent diffusion coefficient and the T2 relaxation constant, responded to different portions of the lesioning process. In particular, T2 weighted lesion contrast appeared to respond as a function of the ferritin and hemoglobin content of the treated tissue. Further, T2 contrast appeared quickly at the onset of treatment and then saturated such that further treatment could not generate more image contrast. Meanwhile, diffusion weighted lesion contrast could form irrespective of iron content and continued to continued to change well after the T2 contrast saturated. This work will prove very useful in analyzing and predicting clinical outcomes of transcranial histotripsy surgeries.

    a. Sukovich JR, Cain CA, Pandey AS, Chaudhary N, Camelo-Piragua S, Allen SP, Hall TL, Snell J, Xu Z, Cannata JM, Teofilovic D, Bertolina JA, Kassell N, Xu Z. In vivo histotripsy brain treatment. J Neurosurg. 2018 Oct 1; PubMed Central PMCID: PMC6925659.
    b. Lundt JE, Allen SP, Shi J, Hall TL, Cain CA, Xu Z. Non-invasive, Rapid Ablation of Tissue Volume Using Histotripsy. Ultrasound Med Biol. 2017 Dec;43(12):2834-2847. PubMed Central PMCID: PMC5693635.
    c. Allen SP, Vlaisavljevich E, Shi J, Hernandez-Garcia L, Cain CA, Xu Z, Hall TL. The response of MRI contrast parameters in in vitro tissues and tissue mimicking phantoms to fractionation by histotripsy. Phys Med Biol. 2017 Aug 18;62(17):7167-7180. PubMed PMID: 28741596.

3. The latest phase of my work has been to improve MR guidance of thermal ablations. Specifically, I wish to use diffusion, arterial spin labeling, and other advanced MR imaging techniques to monitor and analyze thermal ablations in the brain. This is particularly difficult due to the various ways clinical transcranial focused ultrasound devices interfere with MR imaging. This work so far has been focused on improving both MR acquisition methodologies as well as the MR imaging environment used during these procedures. A part of this effort includes the current proposal.

    a. Allen SP, Steeves T, Fergusson A, Moore D, Davis RM, Vlaisialjevich E, Meyer CH. Novel acoustic coupling bath using magnetite nanoparticles for MR-guided transcranial focused ultrasound surgery. Med Phys. 2019 Dec;46(12):5444-5453. PubMed Central PMCID: PMC6899167.
    b. Quah K, Poorman ME, Allen SP, Grissom WA. Simultaneous multislice MRI thermometry with a single coil using incoherent blipped-controlled aliasing. Magn Reson Med. 2020 Feb;83(2):479-491. PubMed Central PMCID: PMC6824936.
    c. Allen SP, Feng X, Fielden SW, Meyer CH. Correcting image blur in spiral, retraced in/out (RIO) acquisitions using a maximized energy objective. Magn Reson Med. 2019 Mar;81(3):1806-1817. PubMed Central PMCID: PMC6859899.

CURRENT AND PENDING (OTHER) SUPPORT INFORMATION

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person.

*NAME: Allen, Steven Paul

*POSITION TITLE: Assistant Research Professor

*ORGANIZATION AND LOCATION: Brigham Young University, Provo, Utah, United States

Projects/Proposals

***Project/Proposal Title:** Eddy Current Correction and Skull Thermometry

***Status of Support:** current

Proposal/Award Number:

***Source of Support:** Focused Ultrasound Foundation

***Primary Place of Performance:** University of Virginia

***Project/Proposal Support Start Date: (MM/YYYY):** 09/2022

***Project/Proposal Support End Date: (MM/YYYY):** 05/2023

***Total Award Amount:** $87,789

*** Person Months (Calendar/Academic/Summer) per budget period Committed to the Project:**

Year	Person Months
2022	0.5
2023	0.1

***Overall Objectives:** The goals of this project are to characterize and remove eddy current artifacts in a manner that can adapt to differences in clinical conditions that vary from site to site and to further clinical translation of 3D thermometry.

***Statement of Potential Overlap:** None

***Project/Proposal Title:** Iron Based Coupling Media (IBCM) for MRI-guided Transcranial Ultrasound Surgeries

***Status of Support:** current

Proposal/Award Number: 1R01EB032773

***Source of Support:** NIH/NIBIB

***Primary Place of Performance:** Brigham Young University

***Project/Proposal Support Start Date: (MM/YYYY):** 09/2022

***Project/Proposal Support End Date: (MM/YYYY):** 08/2026

***Total Award Amount:** $2,156,748

*** Person Months (Calendar/Academic/Summer) per budget period Committed to the Project:**

Year	Person Months
2022	2
2023	2
2024	2
2025	2
2026	0.5

***Overall Objectives:** The goal of this project is to develop novel acoustic coupling media that will improve MRI guidance and safety during focused ultrasound surgical procedures.

***Statement of Potential Overlap:** None

***Project/Proposal Title:** ERI: Magnetic Resonance Imaging of Acoustic Fields for Ultrasound-Based CNS Regeneration

***Status of Support:** current

Proposal/Award Number: 2138403-ERI

***Source of Support:** NSF/DARE

***Primary Place of Performance:** Brigham Young University

***Project/Proposal Support Start Date: (MM/YYYY):** 04/2022

***Project/Proposal Support End Date: (MM/YYYY):** 03/2024

***Total Award Amount:** $198,853

*** Person Months (Calendar/Academic/Summer) per budget period Committed to the Project:**

Year	Person Months
2022	1
2023	1
2024	0.25

***Overall Objectives:** The goal of this project is to construct, validate, and implement a novel electromagnet that can quantify acoustic pressure fields in the CNS.

***Statement of Potential Overlap:** The first stage of work in this proposal has some overlap with the BYU College of Engineering MRE and seed grants. The ERI is a natural extension of the work done in the MRE and seed grants.

***Project/Proposal Title:** Feasibility of transcranial histotripsy for pediatric neuro-oncology applications using a hemispherical transducer

***Status of Support:** current

Proposal/Award Number: R21EB033117

***Source of Support:** NIH/NIBIB

***Primary Place of Performance:** University of Utah

***Project/Proposal Support Start Date: (MM/YYYY):** 04/2022

***Project/Proposal Support End Date: (MM/YYYY):** 12/2024

***Total Award Amount:** $50,177

*** Person Months (Calendar/Academic/Summer) per budget period Committed to the Project:**

Year	Person Months
2022	0.75
2023	1
2024	1

***Overall Objectives:** The overall goal of this Trailblazer R21 project is to develop a histotripsy therapy mechanism for pediatric brain tumors

***Statement of Potential Overlap:** None

***Project/Proposal Title:** The goal of this project is to develop accelerated, nearly 3D MRI thermometry for focused ultrasound and laser thermal ablative surgeries in the brain.

***Status of Support:** current

Proposal/Award Number:

***Source of Support:** BYU Office of Associate Academic Vice President

***Primary Place of Performance:** Brigham Young University

***Project/Proposal Support Start Date: (MM/YYYY):** 01/2022

***Project/Proposal Support End Date: (MM/YYYY):** 12/2023

***Total Award Amount:** $25,000

*** Person Months (Calendar/Academic/Summer) per budget period Committed to the Project:**

Year	Person Months
2022	0.2
2023	0.2

***Overall Objectives:** The goal of this project is to develop accelerated, nearly 3D MRI thermometry for focused ultrasound and laser thermal ablative surgeries in the brain.

***Statement of Potential Overlap:** None

***Project/Proposal Title:** Comprehensive MRI Guidance of Focused Ultrasound Neurosurgery

***Status of Support:** current

Proposal/Award Number: R01EB028773

***Source of Support:** NIH/NIBIB

***Primary Place of Performance:** University of Virginia

***Project/Proposal Support Start Date: (MM/YYYY):** 09/2020

***Project/Proposal Support End Date: (MM/YYYY):** 05/2024

***Total Award Amount:** $526,849

*** Person Months (Calendar/Academic/Summer) per budget period Committed to the Project:**

Year	Person Months
2022	1
2023	1
2024	0.5

***Overall Objectives:** The overall goal of this project is to provide comprehensive MRI feedback for transcranial focused ultrasound to improve the safety, efficiency and efficacy of treatment.

***Statement of Potential Overlap:** None

***Project/Proposal Title:** Passive antennas for improved image quality in transcranial MR-guided focused ultrasound

***Status of Support:** current

Proposal/Award Number: R21EB029639

***Source of Support:** NIH/NIBIB

***Primary Place of Performance:** Vanderbilt University

***Project/Proposal Support Start Date: (MM/YYYY):** 05/2020

***Project/Proposal Support End Date: (MM/YYYY):** 01/2024

***Total Award Amount:** $266,890

*** Person Months (Calendar/Academic/Summer) per budget period Committed to the Project:**

Year	Person Months
2023	0.05

***Overall Objectives:** The overall goal of this Trailblazer R21 project is to improve MR image quality in

transcranial MR-guided focused ultrasound.

***Statement of Potential Overlap:** None

In-Kind Contributions

***Status of Support:** current

***Source of Support:** BYU Department of Electrical and Computer Engineering

***In-Kind Contribution Start Date: (MM/YYYY):** 09/2020

***In-Kind Contribution End Date: (MM/YYYY):** 09/2026

***Summary of In-Kind Contributions:** Support for Student Research Assistant

***U.S. Dollar Value of In-Kind Contribution:** $12,500

Person Month(s) (or Partial Person-Months) Per Year Associated with the In-Kind Contribution:

Year	Person Months
2021	6

***Overall Objectives:** Support of 1 undergraduate student researcher for 6 months of work.

***Statement of Potential Overlap:** None

Certification:

When the individual signs the certification on behalf of themselves, they are certifying that the information is current, accurate, and complete. This includes, but is not limited to, information related to current, pending, and other support (both foreign and domestic) as defined in 42 U.S.C. §§ 6605. Misrepresentations and/or omissions may be subject to prosecution and liability pursuant to, but not limited to, 18 U.S.C. §§ 287, 1001, 1031 and 31 U.S.C. §§ 3729- 3733 and 3802.

Certified by Allen, Steven in SciENcv on 2023-02-03 12:52:21

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Dahl, David B.

eRA COMMONS USER NAME (credential, e.g., agency login): DavidDahl

POSITION TITLE: Professor and Chair of Statistics

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Brigham Young University	B.S.	04/1997	Statistics
Brigham Young University	M.S.	08/1998	Statistics
University of Wisconsin, Madison	Ph.D.	08/2004	Statistics / Biostatistics

A. Personal Statement

The proposed project requires an interdisciplinary team of individuals who are both experts in their field and capable of working productively with those in other disciplines. I have a strong research record in Bayesian nonparametric statistics and statistical computing and their application to the life sciences. I have a history of successful collaborations with nonstatisticians. Starting with my Ph.D. dissertation at the University of Wisconsin-Madison, my statistical research has been solidly rooted in applications for biology, genetics, and biochemistry. Since then, I have collaborated in a variety of interdisciplinary teams. Of note is a long-term collaboration with Dr. Jerry Tsai (biochemist) and Dr. Marina Vannucci (statistician). I was PI on an NIH R01 grant in which we worked intensively on rigorous statistical approaches for protein structure prediction. Together we identify opportunities to further the field and formulate statistical models to address these challenges. I have applied my skills in statistical computing to lead the efforts to efficiently implement statistical methods. My previous experience and expertise make me well-suited to conduct the interdisciplinary research that we propose in this grant application.

B. Positions, Scientific Appointments, and Honors

Positions and Scientific Appointments

2004-2010 Assistant Professor, Department of Statistics, Texas A&M University, College Station, TX
2007-2010 Adjunct Assistant Professor, Department of Biostatistics, University of Texas MD Anderson Cancer Center, Houston, TX
2010-2012 Adjunct Associate Professor, Department of Biostatistics, University of Texas MD Anderson Cancer Center, Houston, TX
2010-2012 Associate Professor, Department of Statistics, Texas A&M University, College Station, TX
2012-2015 Associate Professor, Department of Statistics, Brigham Young University, Provo, UT
2015-present Professor, Department of Statistics, Brigham Young University, Provo, UT
2022-present Chair, Department of Statistics, Brigham Young University, Provo, UT

Other Experience and Professional Memberships

1996-present Member, American Statistical Association
2003-present Member, Institute of Mathematical Statistics
2003-present Member, International Society for Bayesian Analysis

2009-2012 Associate Editor, Bayesian Analysis
2013-2015 Co-Editor, Bayesian Analysis
2021-2023 Member, Board of Directors, International Society for Bayesian Analysis

Honors

1997 Ellis R. Ott Scholarship from the American Society for Quality
1999-2004 National Eye Institute Traineeship in Biostatistics at UW-Madison

C. Contributions to Science

1. One of my major research areas in statistics is Bayesian modeling of complex structures, such as random partitions and feature allocations. These models permit the borrowing of information across subjects to improve prediction and interpretation and to allow inference in situations that are otherwise too sparse. A few of my key publications in this area are:
    a. **D. B. Dahl**, R. Day, J. Tsai (2017), Random Partition Distribution Indexed by Pairwise Information, *Journal of the American Statistical Association*, 112, 721-732. DOI:10.1080/01621459.2016.1165103.
    b. G. L. Page, F. A. Quintana, **D. B. Dahl** (2022), Dependent Modeling of Temporal Sequences of Random Partitions, *Journal of Computational and Graphical Statistics*, 31(2), 614-627. DOI:10.1080/10618600.2021.1987255.
2. Typically, in Bayesian data analysis, a great deal effort is spent on "fitting the model" such as sampling from the posterior distribution of the model (like those cited previously). It is also necessary, however, to summarize the posterior distribution to convey meaningful results. Another area of expertise is the estimation of parameters, partitions, and feature allocations based on posterior samples. A few of my key publications in this area are:
    a. **D. B. Dahl**, M. A. Newton (2007), Multiple Hypothesis Testing by Clustering Treatment Effects, *Journal of the American Statistical Association*, 102, 517-526.
    b. **D. B. Dahl**, D. J. Johnson, P. Müller (2022), Search Algorithms and Loss Functions for Bayesian Clustering, *Journal of Computational and Graphical Statistics*, accepted. DOI:10.1080/10618600.2022.2069779.
3. I have also made contributions to the field of statistical models for protein structure prediction. I was PI on an NIH R01 grant with Dr. Jerry Tsai (biochemist) and Dr. Marina Vannucci (statistician) in which built rigorous statistical approaches for protein structure prediction. Many publications are with my Ph.D. student Kristin Lennox. This collaboration led to 10 publications, the most significant from a statistical perspective are:
    a. K. P. Lennox, **D. B. Dahl**, M. Vannucci, J. W. Tsai (2009), Density Estimation for Protein Conformation Angles Using a Bivariate von Mises Distribution and Bayesian Nonparametrics, *Journal of the American Statistical Association*, 104, 586-596.
    b. K. P. Lennox, **D. B. Dahl**, M. Vannucci, R. Day, J. W. Tsai (2010), A Dirichlet Process Mixture of Hidden Markov Models for Protein Structure Prediction, *Annals of Applied Statistics*, 4, 916-942.
    c. Q. Li, **D. B. Dahl**, M. Vannucci, H. Joo, J. W. Tsai (2016), KScons: A Bayesian Approach for Protein Residue Contact Prediction using the Knob-socket Model of Protein Tertiary Structure, *Bioinformatics*, 32(24): 3774-3781.
4. I also work in the area of efficient algorithms to fit Bayesian nonparametric models. Most notable are my merge-split samplers for random partition models, including these articles:
    a. **D. B. Dahl**, S. Newcomb (2022), Sequentially-Allocated Merge-Split Samplers for Conjugate Bayesian Nonparametric Models, *Journal of Computational Statistics and Simulation*, 92(7), 1487-1511. DOI:10.1080/00949655.2021.
    b. **D. B. Dahl** (2007), Invited Discussion of Jain and Neal's "Splitting and Merging Components of a Nonconjugate Dirichlet Process Mixture Model," *Bayesian Analysis*, 2, 473-478.
5. Nearly all of my papers provide a reference software implementation. To aid other researchers in also providing software for their methods, I have worked in the area of statistical software integrations. For example, I have a paper under review that provides a framework for developing R packages using fast and safe Rust code.

Current and Pending Support

David Dahl

Dr. Dahl has no current research support to report for this IDR proposal. Pending support is listed below.

Project/Proposal Title: Investigating the impact of subcutaneous fat properties on focused ultrasound thermal therapy outcomes
Status of Support: Pending
Source of Support: NIH/NIBIB
Primary Place of Performance: Brigham Young University
Start Date: 06/2023
End Date: 05/2026
Total Award Amount: $ 593,198 (Includes indirect costs)
Time commitment (Person Months): 0.25 months per year

NAME: Porter Jenkins

POSITION TITLE & INSTITUTION: Assistant Professor of Computer Science - Brigham Young Universit

A. PROFESSIONAL PREPARATION - (see PAPPG Chapter II.C.2.f.(i)(a))

INSTITUTION	LOCATION	MAJOR/AREA OF STUDY	DEGREE (if applicable)	YEAR (YYYY)
1) Brigham Young University	Provo, UT	Statistics	BS	2014
2) Penn State University	State College, PA	Computer/Information Science	PhD	2020

B. APPOINTMENTS - (see PAPPG Chapter II.C.2.f.(i)(b))

From - To	Position Title, Organization and Location
2021-Present	Assistant Professor of Computer Science, Brigham Young University, Provo, UT

C. PRODUCTS - (see PAPPG Chapter II.C.2.f.(i)(c)) Products Most Closely Related to the Proposed Project

1) Porter Jenkins, Kyle Armstrong, Stephen Nelson, Siddesh Gotad, J. Stockton Jenkins, Wade Wilkey, Tanner Watts. CountNet3D: A 3D Computer Vision Approach to Infer Counts of Occluded Objects. 2021 IEEE Winter Conference on Applications of Computer Vision (WACV).

2) Porter Jenkins, Hua Wei, Stockton Jenkins, Zhenhui Li. 2022. Bayesian Model-based Offline Reinforcement Learning for Product Allocation. The Thirty-Fourth Annual Conference on Innovative Applications of Artificial Intelligence (IAAI-22)

3) Porter Jenkins, J. Stockton Jenkins, Ahmad Farag, Huaxiu Yao, Suhang Wang, Zhenhui Li. Neural Utility Functions, In Proceedings of the Thirty-fifth AAAI Conference (AAAI 2021). Virtual, 2021

4) Guanjie Zheng, Chang Li, Hua Wei, Porter Jenkins, Chacha Chen, Tao Wen, Zhenhui Li. Knowledge-based Residual Learning, In Proceedings of 30th International Joint Conference on Artificial Intelligence (IJCAI-21). Montreal, Canada, 2021

5) Porter Jenkins, Ahmad Farag, Suhang Wang and Zhenhui Li. Unsupervised Representation Learning of Spatial Data via Multimodal Embedding. In Proceedings of The 28th ACM International Conference on Information and Knowledge Management, Beijing, China, November 3－7, 2019 (CIKM ’19).

*PI/co-PI/Senior Personnel Name: Jenkins, Porter

***Required fields**

Note: NSF has provided 15 project/proposal and 10 in-kind contribution entries for users to populate. Please leave any unused entries blank.

Project/Proposal Section:

Current and Pending Support includes all resources made available to an individual in support of and/or related to all of his/her research efforts, regardless of whether or not they have monetary value.[1] Information must be provided about all current and pending support, including this project, for ongoing projects, and for any proposals currently under consideration from whatever source, irrespective of whether such support is provided through the proposing organization or is provided directly to the individual. This includes, for example, Federal, State, local, foreign, public or private foundations, non-profit organizations, industrial or other commercial organizations, or internal funds allocated toward specific projects. Concurrent submission of a proposal to other organizations will not prejudice its review by NSF, if disclosed.[2]

[1] If the time commitment or dollar value is not readily ascertainable, reasonable estimates should be provided.
[2] The Biological Sciences Directorate exception to this policy is delineated in PAPPG Chapter II.D.2.

Projects/Proposals

1. *Project/Proposal Title : RI: Small: Reinforcement Learning with Small Data

*Status of Support : ☐ Current ◯ Pending ☐ Submission Planned ☐ Transfer of Support

Proposal/Award Number (if available):

*Source of Support: NSF

*Primary Place of Performance : Brigham Young University

Project/Proposal Start Date (MM/YYYY) (if available) : 07/01/2023

Project/Proposal End Date (MM/YYYY) (if available) : 06/30/2026

*Total Award Amount (including Indirect Costs): $ $600,000

*Person-Month(s) (or Partial Person-Months) Per Year Committed to the Project

*Year (YYYY)	*Person Months (##.##)	Year (YYYY)	Person Months (##.##)
1. 2023	3	4. 2026	3
2. 2024	6	5.	
3. 2025	6		

*Overall Objectives : The core of this project is to develop more real-world reinforcement learning methods through 1) algorithms over incomplete and noisy data, (2) novel graph-based representations of trajectories to enable fast adaptation, (3) design novel offline policy evaluation methods.

*Statement of Potential Overlap : No other projects overlap with the current proposal

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. DO NOT EXCEED FIVE PAGES.

NAME: Berrett, Britt

eRA COMMONS USER NAME (credential, e.g., agency login):

POSITION TITLE: Managing Director & Teaching Professor

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE (if applicable)	END DATE MM/YYYY	FIELD OF STUDY
Brigham Young University, Provo, UT	BS	04/1987	Finance
U.S. Senate Labor and Human Resources Committee, Washington, D.C.	Intern	1986	Healthcare Policy
Washington University School of Medicine, St. Louis, Missouri	MHA	04/1989	Health Administration
Washington University School of Medicine/ National Medical Enterprises, Santa Monica, California	Presidents Fellowship	6/1991	Health Administration
University of Texas at Dallas, Richardson, Texas	PHD	5/2009	Public Affairs

A. Personal Statement

I have more than 30 years in health care leadership of which 25 years as a hospital Chief Executive Officer/Administrator in academic centers, for-profit, not-for-profit, faith-based and community hospitals. In addition, I have published “Patients Come Second- Leading Change by Changing How You Lead” which has become a New York Times and Wall Street Journal Best Seller (2013).

Other recent publications include:

1. Journal of Healthcare Management – Volume 66, number 3 * May/June 2021 – Six Dimensions of leading Organizations Forward: Shaping the Stories of Recovery
2. American College of Healthcare Executives – Early Careerists – Your Leadership Development Plan – The First Step in Building Organizational Culture – Q4 2021

B. Positions, Scientific Appointments and Honors

Positions and Scientific Appointments

2022 -	Managing Director and Teaching Professor, Healthcare Leadership Collaborative, Marriott School of Business, Brigham Young University, Provo, UT
2014 - 2022	Director, Center for Healthcare Leadership and Management – Jindal School of Management, University of Texas at Dallas, Richardson, TX
2014-2022	Program Director, Bachelor of Science Healthcare Management – Jindal School of Management, University of Texas at Dallas, Richardson
2012-2014	Adjunct Faculty, Department of Applied Physiology and Sports Management, Southern Methodist University, Dallas Texas.

Honors

2022	Life Fellow – American College of Healthcare Executives
2021-23	Chair, National Advisory Council, BYU Marriott School of Business
2011	Distinguished Alumni Award – University of Texas at Dallas

C. Contribution to Science

1. I am a featured guest lecturer and keynote speaker at national and international conferences. My expertise is in the field of healthcare leadership and organizational culture:
    a. Dignity Health, Health Leaders Conference, McKesson Executive Leadership Summit, O.C. Tanner National Conference, Becker's Review National Meeting, Premier Health, Beryl Health, HFMA, Stericycle National Sales, Celebration Health, Ensign Group, U.S. Naval West Pacific Command, National Association of Neo-Natal Nurses, Southern California ACHE, Memorial Hospital – Sugarland, etc., BJC Leadership Conference, Army Command Team Leaders Development and Training Session - 2016, Centra Health Leadership Conference – Lynchburg, VA 2016, CHRISTUS Health Leadership & Ethics Academy, Leadership Dallas, General Electric Leadership Webinar, North Mississippi Health Leadership Summit, PWC, Lockheed Martin, American Heart Association, Health Wildcatters, Steward Health, ChenMed, UPMC, Alina Health, Centura Health, Catholic Healthcare West, Utah Hospital Association, Health Leaders Magazine
    b. Keynote Speaker at Hospital Associations – Missouri, Tennessee, Louisiana, Dakota, Oklahoma, North Carolina, Alabama, Arkansas, Utah.
    c. American Association for Health Care Human Resources Administration (ASHRA) - Keynote Speaker
    d. University of Texas at Arlington – Student Leadership Retreat 2014 – "Transforming an Organization:
    e. International Conference of Healthcare Leaders, Houston, Texas 2014 – "Stress in Healthcare? Build a Team!"
    f. Korean Hospital Association, Seoul Korea 2014 – "Leading Change by Changing How You Lead" & "Innovation in Healthcare Leadership"
    g. American College of Healthcare Executive Annual Congress – "Patients Come Second" 2009, 2010 & 2011
    h. American College of Healthcare Executive Annual Congress CEO Boot Camp – Co-Presenter with Tom Atchison – 2015, 2016 & 2017
    i. American College of Healthcare Executives Cluster Program – "You Have a Physician Leader – Now What?" Chicago, Orlando & Las Vegas 2016 & 2017

2. I have been actively involved in community events, activities and organizations:
    a. Volunteer Organizations Active in a Disaster (VOAD) – Dallas Chapter – Vice President; Collin County Chapter – Member
    b. Regent for the American College of Healthcare Executives -North Texas – 2007 - 2010; 2010 - 2013
    c. American College of Healthcare Executives – Fellow
    d. Recipient of the Regents Award from the American College of Healthcare Executives
    e. Careflite Board of Directors – 2009-2014
    f. MedSynergies Board of Directors – 2009-2014
    g. University of Texas at Dallas Healthcare Administration Advisory Board
    h. Distinguished Service Award, American College of Healthcare Executives
    i. Greater Dallas Chamber of Commerce (GDCC), Executive Board Member
    j. Dallas Medical Resources, Board Member, 2000-2009
    k. Labor and Human Resources Committee - GDCC, Chairman, 2012
    l. Dallas/Fort Worth Hospital Council, Board Member
    m. Health Industry Council – Dallas/Fort Worth, Board Member, 2000-2014
    n. Green Oaks Psychiatric Hospital – Dallas Texas, Board Member, 2000-2014
    o. Texas Business Education Coalition, Board Member
    p. Ronald McDonald House, Advisory Board Member
    q. University of Texas at Dallas Executive Education Advisory Board
    r. SMU Executive MBA Scholarship Merit & Mentoring Program, Mentor
    s. American Heart Association – Dallas Division, Board Member
    t. City of Dallas Comprehensive Plan Advisory Committee Member
    u. 40 Under 40 Award - Dallas Business Journal
    v. South Bay Human Services Council, Chairman
    w. Modern Healthcare "Up & Comer", 1998
    x. American Heart Association – Chairman, San Diego South County Division
    y. American Heart Association – Volunteer of the Year, San Diego South County Division

Current and Pending Support

Britt Berrett

Dr. Berrett has no current and pending research support to report for this IDR proposal.