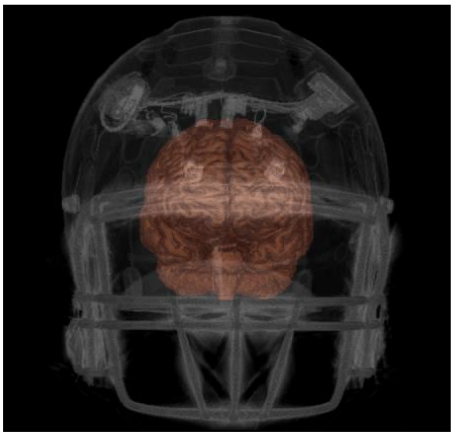
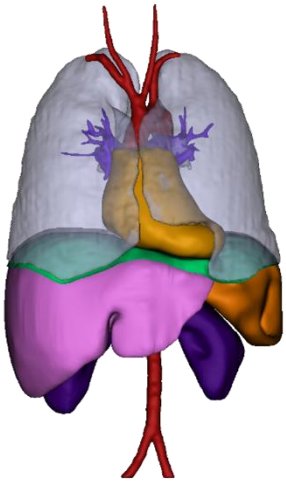
VIRGINIA TECH | WAKE FOREST UNIVERSITY

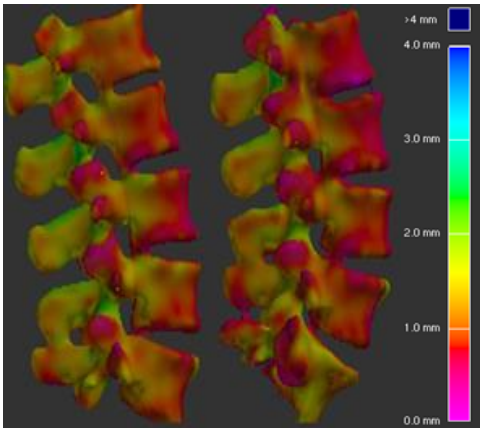
SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

2020

REU Project Descriptions







BME Summer Internship Program

Project List

Project 1: Effect of Weighted Vest Use or Resistance Exercise Training to Minimize Weight Loss Associated Bone Loss in Older Adults (Beavers)

Project 2: Effect of Bisphosphonates on Bariatric Surgery-Associated Bone Loss in Older Adults with Obesity (Beavers)

Project 3: Surgical Robotics and Biomechanics (Brown)

Project 4**:** Additive Manufacturing for Clinical Research Brown)

Project 5: Novel Research and Medical Device Development (Brown)

Project 6: Cancer Center Web Platform (Colvin)

Project 7: Quantifying Postural Differences in Patients with Low Back Injury (Danelson)

Project 8: Development and Validation of a Brain Phantom for Therapeutic Cooling Devices (Gayzik)

Project 9: Underbody Blast Biomechanics (Gayzik)

Project 10: Human Body Model Development for Trauma Research (Gayzik)

Project 11: Identifying High Risk Bladder Cancer Using Machine Learning (Gurcan)

Project 12: Autoscope Review Station (Gurcan)

Project 13: ICU Medication Safety (Kirkendall)

Project 14: Intracranial Monitoring of Sub-second Neurotransmission in Humans (Kishida)

Project 15: Dysplasia Screening Through Image Analysis (Niazi)

Project 16: Identifying Difficult Intubation Patients Using Deep Learning (Niazi)

Project 17: Networked Data Models (Ostasiewski)

Project 18: Data Analysis Pipelines (Ostasiewski)

Project 19: Effect of Improper Valve Sizing on Cardiac Performance (Pierrakos)

Project 20: Computational Fluid Dynamic (CFD) Modeling of Hemorrhage (Rahbar)

Project 21: Sarcopenic Opportunistic CT Metric Correlation with Motor Vehicle Crash Outcomes (Roller)

Project 22: Instrumented Mouthpiece for Head Impact Detection (Stitzel)

Project 23: Diagnosis Mapping and Classification (Topaloglu)

Project List

Project 24: Entity Resolution Framework for Quality (Topaloglu)

Project 25: Dialogflow Clinical Trial Participant Tool (Topaloglu)

Project 26: Biomechanical Evaluation of Head Impact Exposure in Adolescent Athletes (Urban)

Project 27: Vertebral Strength and Injury Risk Following Long-Duration Spaceflight (Weaver)

Project 28: Effect of High Protein Weight Loss Diet on Older Adult Bone Health (Weaver)

Project 29: Image-based Biophysical Modeling to Differentiate Radiation-induced Injury from Tumor Recurrence Following Stereotactic Radiosurgery (Weis)

Project 30: Prevention of Radiation Therapy-Induced Fractures (Willey)

Project 31: Neuroimaging and Cognitive Changes in Youth Football Players (Whitlow)

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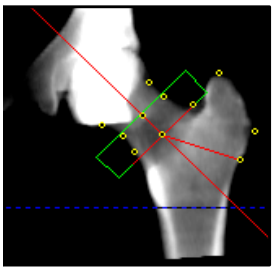
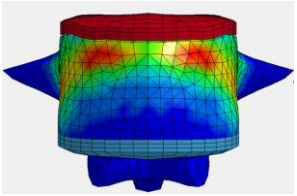
Project 1 - Summer 2020

Effect of Weighted Vest Use or Resistance Exercise Training to Minimize Weight Loss Associated Bone Loss in Older Adults

Osteoporosis is a significant public health problem among older adults and is exacerbated with weight loss. Identification of intervention strategies to minimize weight loss associated bone loss is needed. This NIH funded randomized controlled trial is designed to test whether weighted vest use during a 12 month weight loss intervention attenuates bone loss compared to weight loss alone, and similarly to weight loss plus resistance training (a bone-sparing strategy which is effective, but present barriers to large scale implementation) in 192 older adults with obesity.

The student will: 1) review the literature on weight loss associated bone loss and techniques for measuring bone health using computed tomography (CT), 2) form a hypothesis to test the effect of skeletal loading interventions on CT-derived bone outcome such as bone mineral density (BMD), cortical thickness, bone strength, or fracture risk measured from the hip and spine of study participants (Figure 1), and 3) experimentally test the hypothesis by applying learned CT analysis and finite element (FE) modeling techniques to collect, analyze, and draw conclusions from the resulting bone outcome data.





Location:

Wake Forest® School of Medicine

Kristen M. Beavers, PhD, MPH, RD

Assistant Professor, Department of Health & Exercise Science
Wake Forest University
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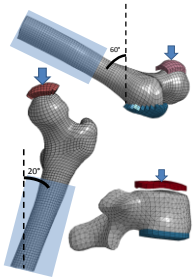
Project 2 - Summer 2020

Effect of Bisphosphonates on Bariatric Surgery-Associated Bone Loss in Older Adults with Obesity

Osteoporosis is a significant concern in older adults with obesity, which may be exacerbated by bariatric surgery due to the magnitude of weight lost and malabsorptive issues. Clinical guidelines support antiresorptive bisphosphonate medication use in bariatric surgery patients with osteoporosis, but no studies have examined the efficacy of oral bisphosphonates to prophylactically attenuate surgical weight loss associated bone loss. This 6-month randomized controlled trial of 24 older (50+ years) sleeve gastrectomy patients will examine the efficacy of bisphosphonate use (versus placebo) in the prevention of surgical weight loss associated bone loss.

The student will: 1) review the literature on bariatric surgery-associated bone loss and techniques for measuring bone health using computed tomography (CT), 2) form a hypothesis to test the effect of bisphosphonate use on a CT-derived bone outcome such as bone mineral density (BMD), cortical thickness, bone strength, or fracture risk measured from the hip and spine of bariatric surgery patients (Figure 1), and 3) experimentally test the hypothesis by applying learned CT analysis and finite element (FE) modeling techniques to collect, analyze, and draw conclusions from the resulting bone outcome data.



Location: Wake Forest School of Medicine

Kristen M. Beavers, PhD, MPH, RD

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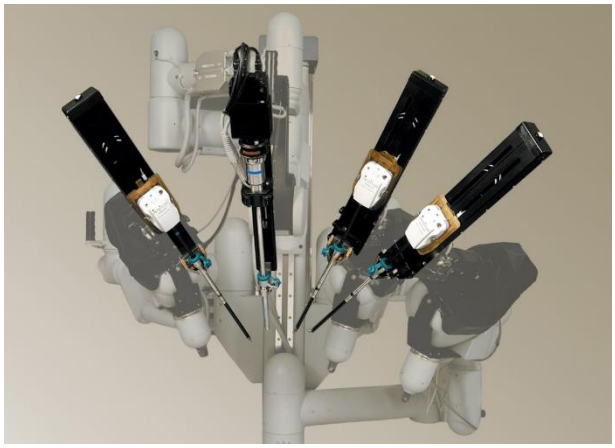
Project 3 - Summer 2020

Surgical Robotics and Biomechanics

Advancements in robotics, computing power, medical imaging and processing, augmented reality, artificial intelligence, motion tracking, and topology scanning are combining to increase the performance and applications of robotic surgery. The trend is driving down system cost and improving effectiveness, and prevalence in care pathways. Biomedical Engineering is fostering opportunities for collaborative research and technology development with physicians and industry partners. We have interest to investigate the following areas of surgical robotics: surgeon to robot interface, force feedback control, autonomous operations, robot tool and tissue interaction, laparoscopic tissue mechanics, surgical instrument design, visualization aids, augmented reality interfaces, training tissue surrogate development, analysis of training and surgical operation, artificial intelligence surgical aids, patient safety, operating room safety & efficiency.



The student will research one or more of these areas by reviewing current understanding and technology development through literature review. This will be followed up by a proposal of novel technology development or pilot research and experimentation. This may including hypothesis formation, experimental design, cadaveric testing, and data analysis. The student will receive training in robot control and any other relevant technical skills. Outcomes from their summer research experience will contribute to proposals for grant funding.

Location: Wake Forest School of Medicine

Philip Brown, PhD

Research Assistant Professor, Biomedical Engineering
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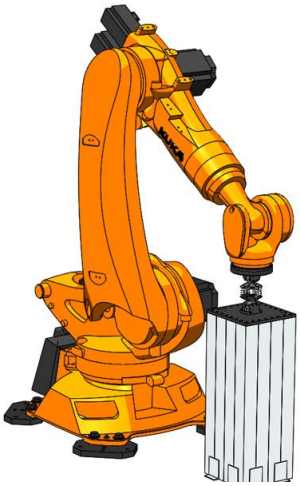
Project 4 - Summer 2020

Additive Manufacturing for Clinical Research

There are several opportunities within Biomedical Engineering and through collaborations with orthopedics, neurosurgery, plastic surgery, and others for the experimental validation and exploration of surgical techniques. These procedures are intended to preserve and/or restore physiological function. Our lab conducts surgical biomechanical experiments on new and standard surgical techniques of repairs to bones, ligaments, tendons, and joints. Students selected for this research area will be heavily engaged in experimental design, fixture design, tissue handling and dissection, instrumentation, material testing, data analysis, as well as maintaining professional partnerships with clinical faculty.



This research effort will be in the Center for Injury Biomechanics (CIB) and you will have the opportunity to work on a range of projects in the field of automobile safety, military restraints, and sports biomechanics. The CIB has two primary research facilities. The first is in the WFU School of Medicine in Winston-Salem, NC and the second is at Virginia Tech. The research at the CIB combines experimental testing, computational modeling, and case analysis to investigate human injury biomechanics.

Location: Wake Forest School of Medicine

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Project 5 - Summer 2020

Novel Research and Medical Device Development

There are several opportunities within Biomedical Engineering and through collaborations with orthopedics, neurosurgery, the center for biomedical imaging, plastic surgery, and others for the development of novel medical and research devices. These include experimental fixtures, exercise/rehabilitation machines and instruments, as well as surgical tools and hardware. Students selected for this project will be heavily engaged in the design process, conceptualization, prototyping, quality assurance, and experimental evaluation of multiple concurrent device development projects.

The student will aid in research and development of novel medical devices and operation of 3D printing support. This will involve review of literature on current and future medical procedures and techniques. The student will receive training in operation of professional software and hardware tools for industry quality CAD and FEA software as well as 3D printing systems. Mechanical material testing and analysis may also be conducted.

Location: Wake Forest School of Medicine

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SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

Project 6 - Summer 2020

Cancer Center Web Platform

Comprehensive Cancer Center is looking for a web platform to replace all of the old .NET and other applications. One major component would be a create, read, update, and delete (CRUD) system to transition existing legacy apps, and to also serve as an application template for rapid, new development in the future. This project involves full stack development and will work closely with senior developers. This will be great learning opportunity for understanding of actual development and cancer informatics.

The student working on this project will gain experience in full-stack software development using a variety of programming languages and database platforms, including Python, SQL, and JavaScript. The software produced will be used throughout the Cancer Center, providing a real-world software engineering opportunity in a production environment.

Required skills: Programming in web services

Location: Wake Forest School of Medicine

T.J. Colvin, MS

Programmer Analyst Staff Specialist,
Comprehensive Cancer Center
Wake Forest School of Medicine
486 N. Patterson Ave, Suite 400
Winston-Salem, NC 27101

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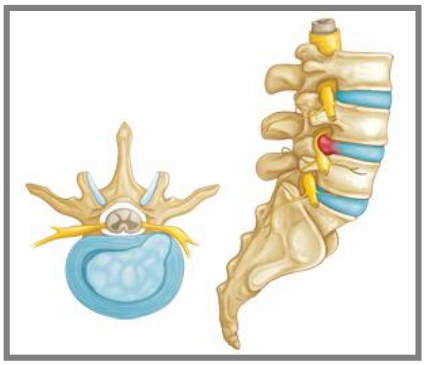
SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

Project 7 - Summer 2020

Quantifying Postural Differences in Patients with Low Back Injury

Lumbar disc herniation from automotive crashes, sports, and workplace injury can lead to recurring back pain. Postural training is a proposed alternative to surgical treatment of lumbar disc injury. This project aims to quantify postural differences between controls and low back injury patients that may be remedied through postural corrective therapies. Subjects will undergo biomechanical monitoring for up to 12 hours to quantify posture during normal activities.

The student will: 1) review literature on the postural effects of low back injury, posture sensing technologies, and postural therapies, 2) form a hypothesis to be tested through collection of postural data from control and injured subjects using a monitoring system, and 3) statistically analyze the monitoring results and identify key postural differences in low back injury patients



Location: Wake Forest School of Medicine

Kerry Danelson, PhD

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kdanelso@wakehealth.edu

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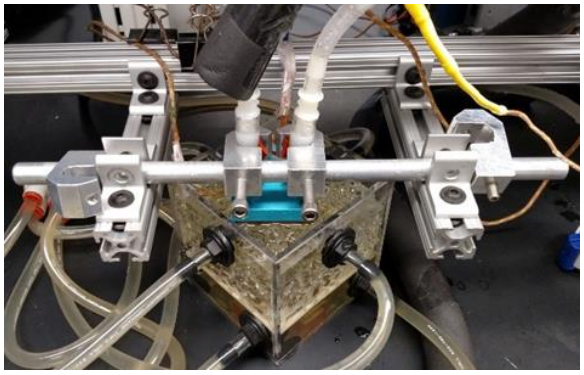
SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

Project 8 - Summer 2020

Development and Validation of a Brain Phantom for Therapeutic Cooling Devices

An emerging area of interest is the study of bio-heat transfer for modeling brain therapeutics and pathology such as epilepsy. This project will focus on the study of heat transfer as it pertains to human body modeling, specifically quantifying thermal dose in the human body based on well-known bio-heat transfer experiments in the literature. The student will conduct experiments on a previously-developed brain phantom which simulates cooling therapy.

Next, using an established finite difference model, the student will calculate the predicted transient temperature response of both the phantom and of a brain, and compare those mathematical results to those from the lab experiment. In conjunction with this effort, the phantom will be improved upon in a laboratory setting in order to ensure repeatability of experiments as well as the ability to match the expected physiological response.



Lastly, the student will be tasked with developing prototypes of novel cooling devices within relevant design criteria. Understanding the context and application of such a device will be key to development.

Location: Wake Forest School of Medicine

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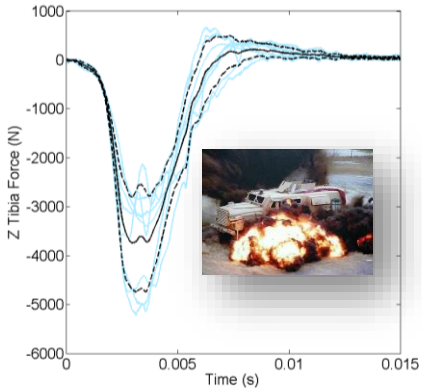
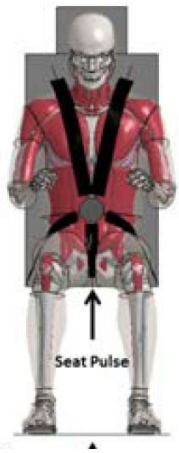
SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

Project 9 - Summer 2020

Underbody Blast Biomechanics

Underbody blast loading creates vertical accelerative loading and is a significant threat to the modern warfighter. The goal of this project is to develop a biomechanically based strategies for mitigating injury in these environments. This includes team oriented work on the development of anthropomorphic testing devices (ATD, aka dummy) with biofidelic capabilities specific to the underbody blast environment. Additionally, human body finite element modeling in this environment will be a component of the project. Human modeling work is focused on the hypothesis that computational human body models can be used this environment to predict injury and thus be used as a novel surrogate to establish preliminary guidelines on human tolerance to severe vertical loading. Component level tests will be evaluated for statistically significant agreement with experimental trials and we will explore the suitably of a modeling approach for foundational biomechanical work in vertical loading. The student will assist in the development and execution of code to generate human injury probability curves, and use of finite element models in matched trials of dummy and laboratory tests.





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Location: Wake Forest School of Medicine

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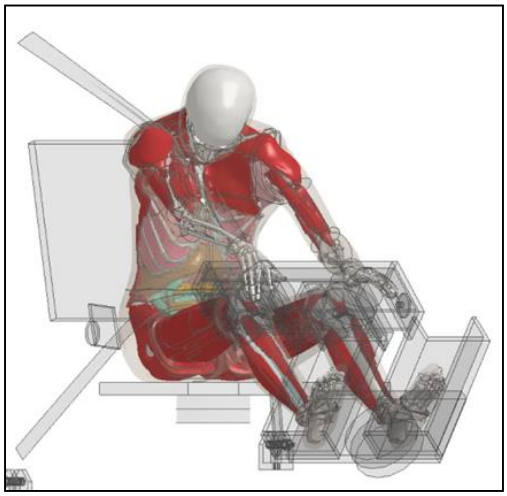
Project 10 - Summer 2020

Human Body Model Development for Trauma Research

Computational modeling is a growing component of injury biomechanics and trauma research. This project is a multi-center effort developing a next generation set of human body finite element (FE) models for enhanced injury prediction and prevention systems. The student will learn specific skills that are highly translatable to future graduate research experience including finite element volume meshing, high performance computing and morphometric operations such as scaling and medical image analysis. There will be a specific emphasis on applying the scientific process to these efforts. Students will review the literature in the subfield of modeling in which they are working. Computational efforts will focus on hypothesis driven activities, with simulations designed and conducted by the student to verify or refute their inquiries. These activities will be focused around model validation, studies related to injury risk predication in a given environment, or how best to scale results to match literature data from different body habitus.



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Location: Wake Forest School of Medicine

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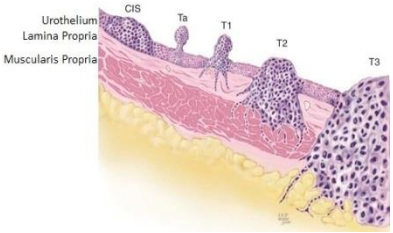
Project 11 - Summer 2020

Identifying High Risk Bladder Cancer Using Machine Learning

Multiple instance learning (MIL) is a general, weakly supervised machine learning technique in which class labels (patient outcome) are assigned to collections of patterns ('bags') instead of individual instances (annotated regions for a certain landmark) of a class. In its simplest form (binary classification), it consists of two bags – one bag is labeled negative where every instance inside it is negative, and the other bag is labeled positive, where it contains at least one positive instance. For example, if a negative bag contains features or images corresponding to the negative class, then a positive bag contains the same kinds of images or features in addition to features or images of the positive class. Only the negative bag requires strictly instances of its own class, whereas the positive bag requires at least one instance of the positive class. Our lab is interested in applying multiple instance learning in conjunction with deep learning to identify T1 bladder cancer patients who are at a high risk of progression to a higher stage.



The student working on this project will create a deep learning implementation of multiple instance learning. This project will involve heavy use of machine learning packages in either Python or C, data augmentation, and basic image analysis methods on a high performance computing cluster environment. The student will work closely with pathologists to understand bladder cancer by learning microscopic anatomy of the bladder, underlying disease state, and staging protocols. The findings of this study may lead to a publication in a medical imaging conference.

Location: Wake Forest School of Medicine

Metin Gurcan, PhD

Director, Center for Biomedical Informatics
Professor, Department of Internal Medicine
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Project 12 - Summer 2020

Autoscope Review Station

Acute infections of the middle ear (acute otitis media – AOM), are the most commonly treated childhood disease. Diagnosing AOM still depends on clinician subjectivity, based on a brief glimpse of the eardrum. This project will fill that gap, by developing computer-assisted image analysis (CAIA) software that provides objective information to a clinician by analyzing eardrum images collected using currently available hardware. This project will develop a review station that will display ear images/videos from a carefully curated database and associated metadata, present processed (e.g. composite images) as well as retrieve most visually similar images using content-based image retrieval methods

As part of this project, the student will have the opportunity to work with professionals from distinct fields (machine learning, image analysis, and otolaryngology). The student will develop an automated image retrieval system to retrieve visually similar images. In order to develop the review station, the student shall have the liberty to use the package of his / her choice. The results of this research may lead to publishing at a medical imaging conference.
Required skills: MATLAB, Python

Location: Wake Forest School of Medicine

Metin Gurcan, PhD

Director, Center for Biomedical Informatics
Professor, Department of Internal Medicine
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SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

Project 13 - Summer 2020

ICU Medication Safety

The overarching goal is to use data from the electronic health record and smart infusion pumps to detect potential errors in the administration of high-risk medications. This work has been in process since 2011 at Cincinnati Children's Hospital Medical Center (CCHMC), the former institution of the Principal Investigator, Dr. Eric Kirkendall. Dr. Kirkendall continues to lead the team at CCHMC and is working to spread the work to Wake Forest Baptist Medical Center.

Aim 1: R01-funded work to compare NICU medication order and Medication Administration Record (MAR) data in real-time and notify clinicians when there is a discrepancy (possible error)

Aim 2: Studying the portability of the work into other NICUs and adult ICU settings.

Aim 3: Incorporating smart infusion pump data into Med Administration error detection algorithms, so could compare order, med administration record (MAR) and smart pump data.

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The student who joins our team will learn and/or perform one or more of the following activities:

- Cleaning and preparation of large datasets
- Basic and advanced data analytics
- Software prototyping & development
- Software implementation and evaluation
- IRB application & manuscript preparation

Location: Wake Forest School of Medicine

Required skills: Python, SQL

Eric Kirkendall, MD, MBI

Associate Professor – Pediatric Hospital Medicine
Deputy Director and Director of Digital Health Innovation
Center for Healthcare Innovation
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450 N. Patterson Ave, Suite 400
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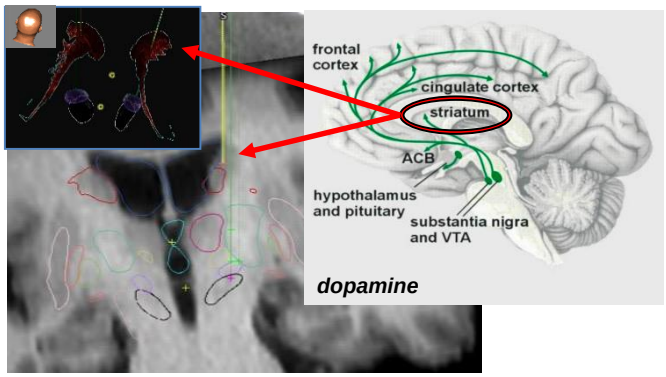
Project 14 - Summer 2020

Intracranial Monitoring of Sub-second Neurotransmission in Humans

Choice behavior and associated conscious experiences are fundamental problems in philosophy, neuroscience, and mental health research. To investigate the neurochemical basis of learning, adaptive choice behavior, and associated subjective experiences in humans we directly monitor dopamine, serotonin, and norepinephrine neurotransmission in the human brain while participants perform mathematically constrained games. This project will support these efforts by developing new tools for simultaneously monitoring multiple neurotransmitter systems with sub-second temporal resolution throughout the human brain during conscious choice behavior.



*Dopamine neurons (**green** cartoon) in the midbrain send projections throughout the human brain and highly innervate the striatum (**red** in cartoon, MRI, and inset 3D reconstruction). Electrodes acutely implanted during human brain surgery (trajectory shown in yellow) detect dopamine fluctuations with 10Hz or faster temporal resolution.*

The student working on this project will be trained in wet-lab procedures including electrode manufacture, solution preparation, and voltammetry data collection in computer controlled flow cells. Further, the student will use Matlab to implement machine learning algorithms to fit models that relate voltammetric measurements to chemical species identity and estimates of concentration. Students may also be involved in development of a new computer controlled system to make measurements from multiple electrodes simultaneously.

Location: Wake Forest School of Medicine

Kenneth T. Kishida, PhD

Assistant Professor, Physiology and Pharmacology
Assistant Professor, Neurosurgery
Assistant Professor, Biomedical Engineering
Wake Forest School of Medicine,
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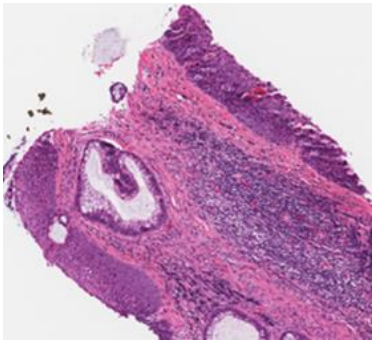
Project 15 - Summer 2020

Dysplasia Screening Through Image Analysis



We will develop a machine learning software to automatically screen anal dysplasia patients from histopathological images. We will develop a unique variant of conditional generative model (cGAN) for screening of anal dysplasia patients. We will train two independent cGANs; the first will be trained to reconstruct histopathological images of low grade patients, while the second will be trained to reconstruct histopathological images of high grade anal dysplasia patients. To classify a test image, both cGANs will attempt to reconstruct the test image from its latent space representation. Whichever cGANs reconstructs the test with the highest structural similarity index will be chosen as the 'winner.'

The project will help develop deep understanding of concepts in digital pathology and deep learning. The student will develop an automated method to differentiate low and high grade patients using deep learning and sophisticated image analysis methodologies. This task will be executed on a high performance computing cluster using machine learning package of the student's choice and Python. The student will closely work with experts in machine learning, infectious disease, and pathology. The findings of this study may lead to a publication in a medical imaging conference.

Required skills: MATLAB, Python

Location: Wake Forest School of Medicine

Khalid Niazi, PhD

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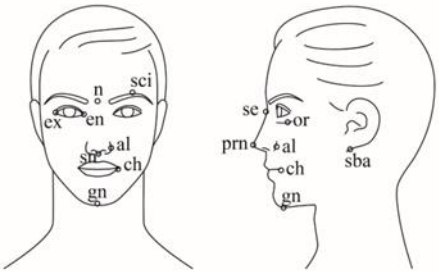
Project 16 - Summer 2020

Identifying Difficult Intubation Patients Using Deep Learning

Successful airway management is fundamental to safe anesthetic performance, and airway management failure continues to be the leading cause of anesthesia-related death and severe morbidity. In this project, we suggest that a deep learning system based on analysis of facial photographs could outperform conventional bedside tests and improve airway management and patient safety.



As part of this project, the student will get a chance to work with experts from different domains (machine learning, anesthesiology, and bio-statistics). The student will create an automated method for identifying points of interest (features) from facial images for the detection of patients who may suffer from difficult intubation. This will be accomplished through deep learning methodologies including data pre-processing, data generation, artificial neural networks, and cross-validation. This task will be executed on a high performance computing cluster using machine learning package of the student's choice and Python. The findings of this study may lead to a publication in a medical imaging conference.

Required skills: MATLAB, Python

Location: Wake Forest School of Medicine

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Project 17 - Summer 2020

Networked Data Models

Electronic Medical Records (EMRs) are aimed at supporting clinical practice at the point of care. These are often deeply customized and unique to the institutions in which they operate. Therefore, when conducting research with collaborators at other institutions it is often difficult to execute systematic analysis of these disparate observational databases. Common Data Models (CDMs) allow transformation of data contained within these databases into a common format as well as a common representation (terminologies, vocabularies, coding schemes), which then allows systematic analyses using a library of standard analytic routines that have been written based on the common format. The CTSI at Wake Forest leads and participates in several of these regional and national networks sharing data for basic science, retrospective studies, and clinical trial recruitment.

The student working on this project will be trained in data analytics and supporting application programming. The student will get familiarity with national medical data standards, ontological systems, and the full-cycle process of research from cohort identification to data extraction and analysis. Data characterization, cleaning, Natural Language Processing (NLP), and visualization will be explored. Prior experience with application programming, databases, and statistics is helpful.

Location: Wake Forest School of Medicine

Brian Ostasiewski

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Project 18 - Summer 2020

Data Analysis Pipelines

Beyond the essential coded data elements in Electronic Medical Records (EMRs), additional metadata and analog data provide opportunities for better patient evaluation and care, if those elements can be easily incorporated into research data warehouses. This metadata includes sources such as Digital Imaging and Communications in Medicine (DICOM) file headers, which can be indexed for easy cohort identification by otherwise unavailable variables such as radiation dosage levels or image series size. Based on a cohort, large images can be retrieved from the Picture Archiving and Communication System (PACS) systems and analyzed in a plug-and-play serial pipeline that minimizes the need for massive storage. Similarly, textual data can be mined with advanced targeted analysis as an injected step within the larger Natural Language Processing (NLP) concept extraction process.

The student working on this project will be trained in data analytics and supporting application programming. The student will get familiarity with national medical data standards, ontological systems, and the full-cycle process of research from cohort identification to data extraction and analysis. Data characterization, cleaning, NLP, and visualization will be explored. Python programming is required. Prior experience with databases, statistics, and image analysis is helpful.

Location: Wake Forest School of Medicine

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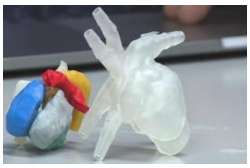
Project 19 - Summer 2020

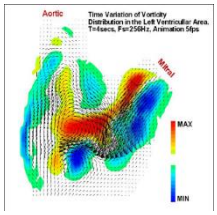
Effect of Improper Valve Sizing on Cardiac Performance

Improper sizing of heart valves often leads to insufficient valve performance and the need for re-operation. Existing methods provide little hemodynamic justification for the selection of devices and the impact to the cardiovascular system as a whole. This study aims to investigate impact of improper valve selection on the hemodynamic performance of the cardiac system as a whole. Hemodynamic performance of different heart valves will be analyzed using echocardiography-derived anatomical models (3D printed) and a heart simulator test apparatus (under both health and diseased conditions).

Prosthetic Heart Valve



3D Printed Cardiac Model



Cardiovascular Fluid Flow Analysis

Pulse Duplicator for Hemodynamic Testing of Heart Valves

The student working on this project will be trained in cardiovascular fluid mechanics (hemodynamics), engineering standards criteria, and cardiovascular device test methodology (using heart simulator). The student will form a hypothesis to test the effects of nutrition and weight loss on bone. To test the hypothesis, hemodynamic performance of heart valves will be analyzed for both healthy and diseased conditions.

Location: Wake Forest School of Medicine

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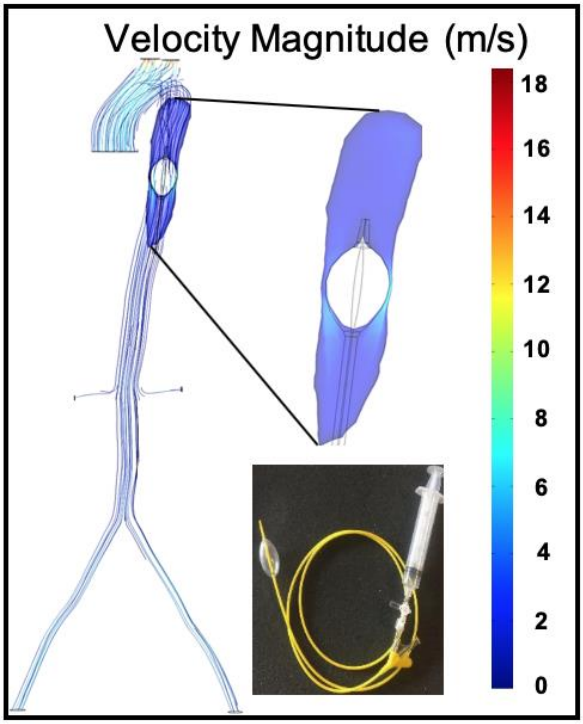
Project 20 - Summer 2020

Computational Fluid Dynamic (CFD) Modeling of Hemorrhage

Non-compressible hemorrhage, referring to regions of the body that cannot be tourniquet pose a serious threat to one's survival. To address this problem, Endovascular Aortic Control (EVAC) devices have been implemented to create a partial occlusion of the aortofemoral artery via inflation of a balloon catheter. However, these methods are of high risk, often resulting in significant ischemic injury and vascular collapse. This project exploits CFD modeling to better understand the hemodynamics during hemorrhage and EVAC implementation.



The student will: 1) review literature on hemorrhagic shock, 2) design a hypothesis-driven project to evaluate the efficacy of EVAC devices, and 3) apply learned CFD and FE skills to quantify key fluid mechanics properties (e.g. shear stress, blood pressure) in the aortofemoral region. This data will help inform improved designs of EVAC devices, ensuring the restoration of blood pressure and fluid flow, while delivering sufficient oxygen to mitigate ischemic injury.

Location: Wake Forest School of Medicine

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Project 21 - Summer 2020

Sarcopenic Opportunistic CT Metric Correlation with Motor Vehicle Crash Outcomes

Sarcopenia manifests in imaging as generalized muscle atrophy and fat infiltration, and is a strong predictor of mortality after trauma patients are discharged. With over 80 million CT scans performed annually in the U.S., opportunistic sarcopenia screening can identify vital risk factors to inform patient treatment. This project will examine CT-acquired muscle and adipose metrics in relation to patient outcomes in 800+ motor vehicle crash occupants in the Crash Injury Research and Engineering Network (CIREN).

The student will: 1) attend CIREN case reviews where engineers and physicians analyze crash, radiology, and medical evidence to determine occupant injury mechanisms, 2) review manual and automated CT methods for measuring sarcopenia, and literature correlating sarcopenia to trauma outcomes, and 3) design and conduct a hypothesis-driven project to determine the relationship between CT-derived sarcopenia metrics (densities and cross-sectional areas of muscle, visceral fat, and subcutaneous fat) and CIREN occupant outcomes (e.g. days hospitalized, ventilator days, mortality, functional health). The student's contributions will lead to automated CT algorithms for sarcopenia characterization, and screening techniques to identify trauma patients at high risk for adverse outcomes.

Location: Wake Forest School of Medicine

Brandon Roller, MD, PhD

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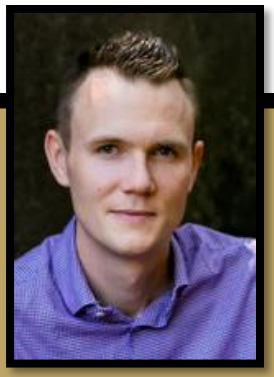

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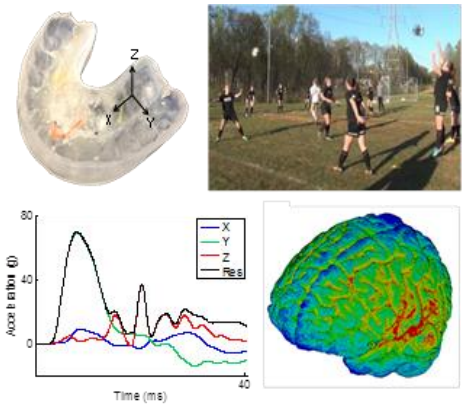
Project 22 - Summer 2020

Instrumented Mouthpiece for Head Impact Detection

Sensor technology offers researchers and consumers the ability to collect head impact data in the real-world; however, the accuracy of such sensors has been limited. This project involves development, testing, and field deployment of a novel instrumented mouthpiece in contact sports (e.g. football, soccer, hockey) and everyday activities (e.g. sitting, running).



The student will: 1) review literature on head kinematics in athletic and everyday activities, and 2) design a hypothesis-driven project to evaluate kinematic data collected from the mouthpiece. The student will apply skills they learn in human subjects' research, experimental testing, data collection and processing, statistical analysis, and FE modeling with a brain model to derive conclusions and a better understanding of head kinematics and TBI risk in sports and everyday activities.

Location: Wake Forest School of Medicine

Joel Stitzel, PhD

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Project 23 - Summer 2020

Diagnosis Mapping and Classification

Diagnosis data is crucial to clinical data reuse and learning from experience in healthcare. However, diagnosis coding structures are not standardized across healthcare systems. In this project, we will attempt to gain a better understanding of this problem by comparing diagnosis classification structures (i.e., source diagnoses, diagnosis type(s) and Oncotree mappings). This work rests on published work. (https://www.ncbi.nlm.nih.gov/pubmed/29888044)

The student working on this project analyze mappings to identify differences, commonalities, problems and clusters using tools such as R and Python. This work is likely to yield, beyond high-level oncology informatics experience, a multi-site publication.

Location: Wake Forest School of Medicine

Umit Topaloglu, PhD, FAMIA

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Project 24 - Summer 2020

Entity Resolution Framework for Quality

Clinical data in Electronic Health Records (EHRs) employs collection of methods and systems often produces highly dissimilar data with varying quality. Poor data quality can result in the inefficient use of research data or can even require the repetition of the performed studies, a costly process. This work will focus on two tools for improving data quality of clinical research data relying on the National Institutes of Health's Common Data Elements as a standard representation of possible questions and data elements to 1) automatically check for conformance to a CDE on semantic and syntactic analysis utilizing the Unified Medical Language System (UMLS) Terminology Services' Metathesaurus and 2- annotate and constrain new clinical research questions though a simple-to-use "CDE Browser."

In this work, the student will build and test these tools on the clinical data analyzed and identified to contain various data quality issues captured by the EHR.

Required skills: Programming in R or Python, SQL and web services

Location: Wake Forest School of Medicine

Umit Topaloglu, PhD, FAMIA

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Project 25 - Summer 2020

Dialogflow Clinical Trial Participant Tool

Dialogflow is a natural language understanding platform that makes it easy to design and integrate a conversational user interface into mobile app, web application, device, bot, interactive voice response system etc. Using Dialogflow, we will provide new and engaging ways for users to interact with clinical studies that are currently at the Wake Forest Health Sciences.

Required skills: Programming in R or Python, SQL and web services

Location: Wake Forest School of Medicine

Umit Topaloglu, PhD, FAMIA

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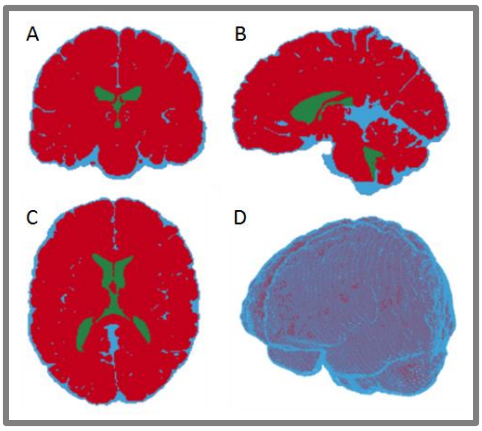
Project 26 - Summer 2020

Biomechanical Evaluation of Head Impact Exposure in Adolescent Athletes

Due to rising concern of head impact exposure and concussion in the 21 million children involved in team sports, this project aims to examine the biomechanical basis of sub-concussive and concussive head impact exposure in adolescent athletes instrumented with helmet-mounted and mouthpiece sensors.

The student will: 1) review literature focused on cumulative exposure of sub-concussive and concussive head impacts and factors influencing exposure (e.g. coaching techniques; practice and game guidelines/rules; community-based interventions; athlete age, size, experience, and position), and 2) design a hypothesis-driven experiment to examine analytically and computationally-based metrics of head impact exposure using FE modeling, on-field video analysis, biomechanical data processing, and statistical approaches learned from mentored training. The student will directly contribute to the broader research goal of reducing sub-concussive and concussive head impact exposure to improve sport safety in adolescents



Location: Wake Forest School of Medicine

Jillian Urban, PhD

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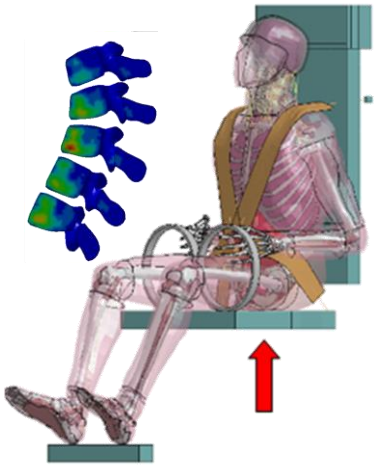
Project 27 - Summer 2020

Vertebral Strength and Injury Risk Following Long-Duration Spaceflight

Prolonged spaceflight can degrade the vertebrae and spinal muscles, leading to astronaut injury. This study is collecting pre- and post-flight CT and magnetic resonance imaging (MRI) scans of astronauts to quantify vertebral BMD, cortex thickness, geometry, and spinal muscle volume changes in 6-month space missions. Vertebral strength and injury risk will be quantified from simulations with a human body model altered to represent each astronaut's pre- and post-flight vertebrae and spinal muscles

The student will: 1) review literature on astronaut musculoskeletal deconditioning and form a hypothesis to test the effect of spaceflight on a bone or muscle outcome, and 2) learn image segmentation and registration, BMD and cortical thickness algorithms, and FE modeling to analyze pre- to post-flight changes in the astronauts to improve our understanding of injury risks associated with spaceflight deconditioning



Location: Wake Forest School of Medicine

Ashley Weaver, PhD

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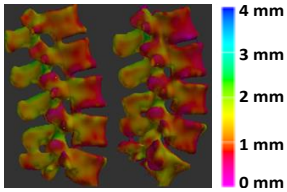
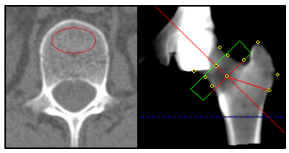
Project 28 - Summer 2020

Effect of High Protein Weight Loss Diet on Older Adult Bone Health

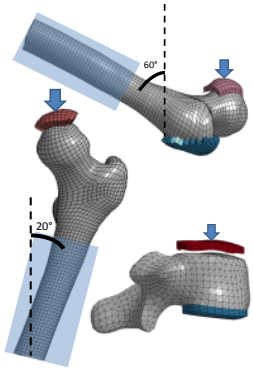
Weight loss is controversial in older adults due to its association with bone loss and increased fracture risk. This clinical trial aims to determine whether a high protein diet during and following weight loss will reduce loss of bone mineral density, bone thickness, and bone strength and decrease fat cells in the bone marrow in older adults with obesity. CT scans of 225 older adults randomized to low vs. high protein weight loss diets will be analyzed to quantify bone health. Subject-specific finite element models created from the CT data will be used to predict femur and vertebra strength and fracture risk.



Cortical Thinning with Weight Loss



Bone Mineral Density Measurement



Finite Element Modeling of Falls and Physiological Loading for Strength and Fracture Prediction

The student working on this project will be trained in image segmentation, image registration, pipelines for quantifying bone quality (i.e. cortical thickness, bone mineral density), and finite element modeling and simulation. The student will form a hypothesis to test the effects of nutrition and weight loss on bone. To test the hypothesis, CT of participants will be analyzed to measure the changes that occur from baseline, 6-month, and 18-month CT scans.

Location: Wake Forest School of Medicine

Ashley Weaver, PhD

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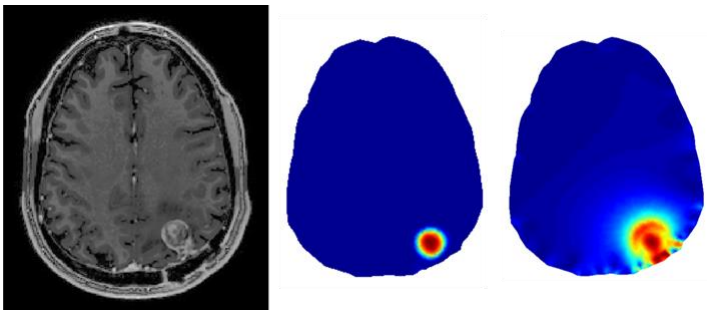
Project 29 - Summer 2020

Image-based Biophysical Modeling to Differentiate Radiation-induced Injury from Tumor Recurrence Following Stereotactic Radiosurgery

Patients with intracranial metastasis treated with stereotactic radiosurgery (SRS) are evaluated for local control using serial MR imaging. Lesions can often be seen during these follow-up imaging sessions with expanding areas of contrast enhancement and surrounding tissue abnormality. Determining the underlying pathology of the lesion presents enormous clinical challenges as tumor recurrence and radiation-induced injury appear radiographically similar. Lesions are often classified as indeterminate and monitored with additional and costly serial follow-up imaging, at the risk of letting a potential recurrent tumor progress. New methods are desperately needed to guide therapeutic intervention decision-making in this important patient group. This project investigates the development of computational modeling methods that are driven by clinical imaging data. As the underlying physiology of the two conditions is fundamentally different, biophysical models may allow parameterization of lesion properties as a model-based biomarker to determine post-SRS enhancing lesion etiology, reducing costs due to unnecessary imaging or missed diagnosis.

The student will gain experience with medical image processing (segmentation, registration) and biophysical finite element modeling based on MRI data. The student will develop and deploy computational analysis pipelines and contribute to the development of computational model-based image analysis methodologies to guide interventional therapy for cancer patients.



Location: Wake Forest School of Medicine

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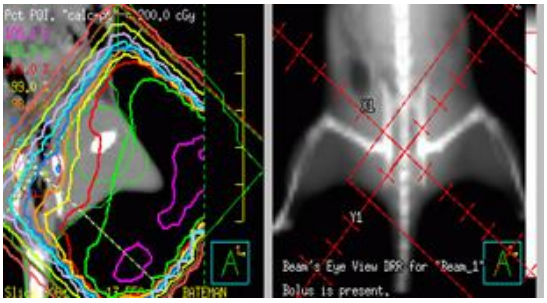
Project 30 - Summer 2020

Prevention of Radiation Therapy-Induced Fractures

Cancer survivors increasingly experience skeletal fractures following radiation therapy (RT), as demonstrated by increased femoral neck and pelvic fractures in postmenopausal women irradiated for cervical (+66%), rectal (+65%), and anal (+216%) cancers by five years post-RT. An early increase in active bone resorption by osteoclasts occurs after RT, which persists and likely leads to fractures. However, no interventions exist because of toxicities associated with antiresorptive therapies and RT, including osteoradionecrosis. This project will determine if a novel compound, 4μ8c, is a well-tolerated, translatable intervention to prevent radiation-induced osteoclast activity, differentiation, and bone loss. 4μ8c inhibits the activity of inositol requiring ER-to-nucleus signal kinase-1 (IRE-1α), which enhances osteoclast differentiation and activity.

The student will: 1) review literature on the effects of RT, 4μ8c, and IRE-1α on osteocytes, and learn about bone remodeling assays (molecular, biochemical, imaging, biomechanical), 2) design a hypothesis-driven study to determine if pretreatment with 4μ8c prevents RT-induced osteoclast differentiation and activity in vitro, and vivo, and 3) perform molecular, cytologic, resorption, microCT, and biomechanical experiments to test the hypothesis and draw conclusions to inform treatment recommendations to prevent RT-induced bone loss and fracture.



Location: Wake Forest School of Medicine

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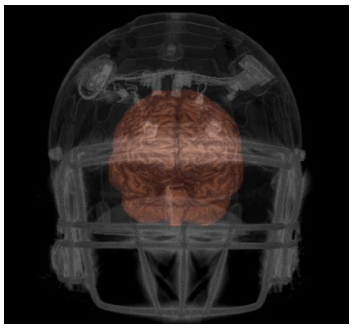
Project 31- Summer 2020

Neuroimaging and Cognitive Changes in Youth Football Players

Sports-related head impacts are common and involve significant forces that can result in mild to severe traumatic brain injury (TBI). Football has the highest incidence of sports-related TBI and limited data is available for the effects of repetitive head impact exposure for the millions of participants in youth and adolescent football leagues (8-18 years old) during this time of rapid brain development. We obtain functional/structural magnetic resonance imaging (MRI), magnetoencephalography (MEG), and cognitive measures, as well as detailed biomechanical head impact data from sensors embedded within the helmets of youth and adolescent athletes to determine the effects of repetitive subconcussive head impact exposure, and the true incidence of cognitive and objective imaging changes. The student selected will perform literature review focused on changes in the brain measureable from imaging and cognitive testing that are associated with cumulative head impact exposure and subconcussive head impacts.

The student will: 1) review literature on impact-induced changes in the brain that are measurable with neuroimaging and cognitive testing, and 2) develop a hypothesis-driven project to correlate neuroimaging measures, cognitive testing, and biomechanical head impact data in youth football players. The student will be trained in multimodal imaging acquisition and analysis (diffusion tensor imaging, functional MRI, arterial spin label imaging, susceptibility weighted imaging, magnetoencephalography), cognitive testing, biomechanical instrumentation (helmet-mounted accelerometers), and statistical analysis. They will apply these skills in their project to analyze youth football data to identify neuroimaging and cognitive biomarkers that are sensitive to cumulative sub-concussive head impact exposure in youth football.



Location: Wake Forest School of Medicine

Christopher T. Whitlow, MD, PhD, MHA

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Director, Radiology Informatics and Image Processing Laboratory (RIIPL)
Director, CTSI Translational Imaging Program
Director, Combined MD/PhD Program
Departments of Radiology and Biomedical Engineering
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