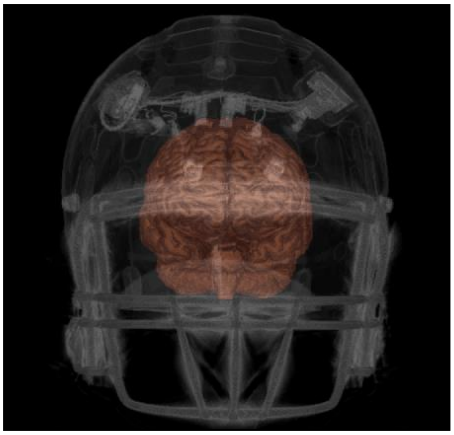
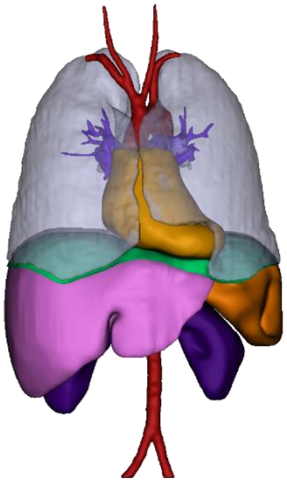
VIRGINIA TECH | WAKE FOREST UNIVERSITY

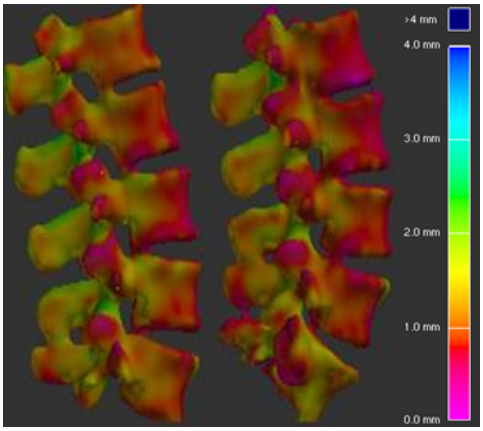
SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

2021

REU Project Descriptions







BME Summer Internship Program

Projects

Project 1:	Effect of Weighted Vest Use or Resistance Training to Minimize Weight Loss Associated Bone Loss in Older Adults (Beavers)
Project 2:	Additive Manufacturing for Clinical Research (Brown)
Project 3:	Novel Research and Medical Device Development (Brown)
Project 4:	Surgical Robotics and Biomechanics (Brown)
Project 5:	Cancer Center Web Platform (Colvin)
Project 6:	Characterization of Subcutaneous Pelvic Adipose Tissue for Enhancement of Human Surrogate Models (Gayzik)
Project 7:	Development and Validation of Brain Phantom for Therapeutic Cooling Devices (Gayzik)
Project 8:	Human Body Model Development for Trauma Research (Gayzik)
Project 9:	Underbody Blast Biomechanics (Gayzik)
Project 10:	Autoscope Review Station (Gurcan)
Project 11:	Identifying High Risk Bladder Cancer Using Machine Learning (Gurcan)
Project 12:	Molecular Detection and Analysis of Trauma Bioindicators (Hall)
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:	Impact of Kinematics and Ball Weight on Shoulder and Elbow Stress During Weighted Ball Drills (Nicholson)
Project 18:	Data Analysis Pipelines (Ostasiewski)
Project 19:	Networked Data Models (Ostasiewski)
Project 20:	Effect of Improper Valve Sizing on Cardiac Performance (Pierrakos)
Project 21:	Computational Fluid Dynamic (CFD) Modeling of Hemorrhage (Rahbar)
Project 22:	Crash Injury Research and Engineering Network [CIREN] (Stitzel)
Project 23:	Head Impact Exposure Quantification and Mitigation in Motorsports (Stitzel)
Project 24:	Subconcussive Head Impact Analysis using Instrumented Mouthpiece Data (Stitzel)
Project 25:	Clinical Trial Activation Prediction Models (Topaloglu)
Project 26:	Deep Learning Cancer Health Disparities (Topaloglu)
Project 27:	Diagnosis Mapping and Classification (Topaloglu)
Project 28:	Dialogflow Clinical Trial Participant Tool (Topaloglu)
Project 29:	Entity Resolution Framework for Quality (Topaloglu)
Project 30:	Tumor Tissue Biobank (Topaloglu)
Project 31:	Biomechanical Evaluation of Head Impact Exposure in Adolescent Athletes (Urban)
Project 32:	Effect of High Protein Weight Loss on Older Adult Bone Health (Weaver)
Project 33:	Vertebral Strength and Injury Risk Following Long-Duration Spaceflight (Weaver)
Project 34:	Image-based Biophysical Modeling to Differentiate Radiation-induced Injury from Tumor Recurrence Following Stereotactic Radiosurgery (Weis)
Project 35:	Diabetes Registry (Wells)
Project 36:	Neuroimaging and Cognitive Changes in Youth Football Players (Whitlow)
Project 37:	Prevention of Radiation Therapy-Induced Fractures (Willey)

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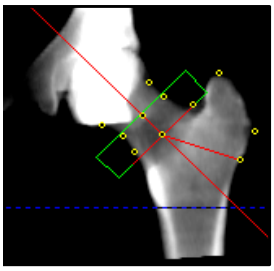
SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

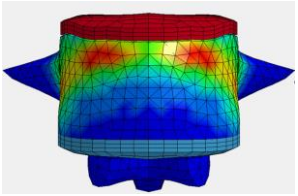
Project 1 - Summer 2021

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

Associate Professor, Department of Health & Exercise Science
Wake Forest University
Winston-Salem, NC 27109
http://hes.wfu.edu/beavers.htm

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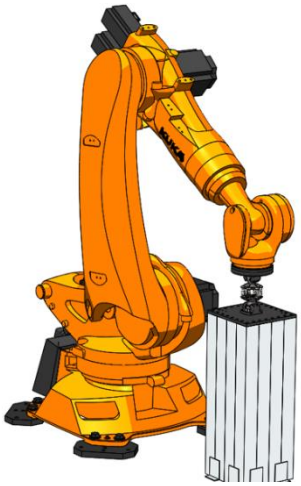
Project 2 - Summer 2021

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

Philip Brown, PhD

Research Assistant Professor, Biomedical Engineering
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SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

Project 3 - Summer 2021

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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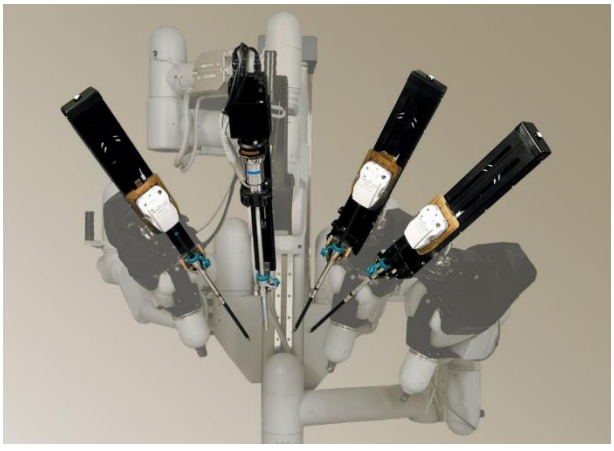
Project 4 - Summer 2021

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 include 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

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Project 5 - Summer 2021

Cancer Center Web Platform

The Comprehensive Cancer Center is building a web platform to replace old .NET systems and other applications. One major component is 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 working closely with senior developers. This will be a great learning opportunity for understanding software development and an introduction to 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: Python and SQL.
Experience with web services desired, but not required.

Location: Wake Forest School of Medicine

T.J. Colvin, MS

Programmer Analyst Staff Specialist,
Comprehensive Cancer Center
Wake Forest School of Medicine
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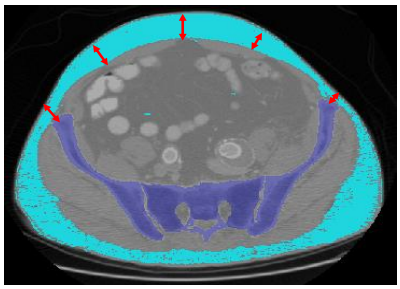
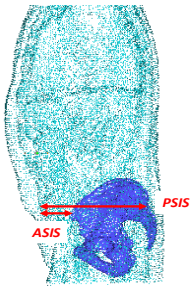
SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

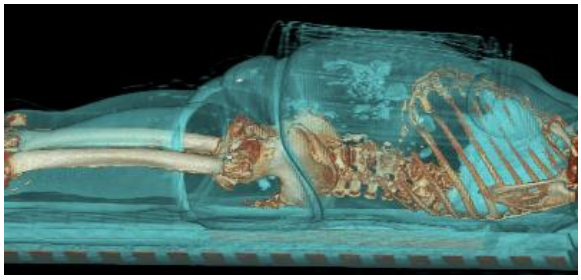
Project 6 - Summer 2021

Characterization of Subcutaneous Pelvic Adipose Tissue for Enhancement of Human Surrogate Models

Occupant submarining occurs mainly in frontal motor vehicle crashes when the lap belt slides over the ASIS of the pelvis. The issue of submarining has become more urgent given the potential of highly autonomous vehicle occupants to recline more frequently or for longer durations when compared to traditional seating postures. Human body models present the unique opportunity to study the risks associated with reclined seating and would greatly benefit from studies characterizing the morphology and quality of adipose tissue in the ASIS region. This study involves analysis of subcutaneous adipose tissue (SAT) in medical imaging scans in supine and seated postures. Linear regression will be used to develop relationships between subject characteristics (BMI, sex, and age) and four quantitative measures of SAT: cross sectional area (CSA_{SAT}), adipose tissue depth to boney prominences like the ASIS, posterior superior iliac spine (PSIS), or others ($D_{SAT,1,2..N}$), fat quality (Q_{SAT} by grayscale unit), and seat belt sign location distance to ASIS (SBL).







The student working on this project will be trained in collecting measurements from abdominal-pelvic CT and/or MRI medical images, and statistical analysis of data collected from human subjects.

Location: Wake Forest School of Medicine

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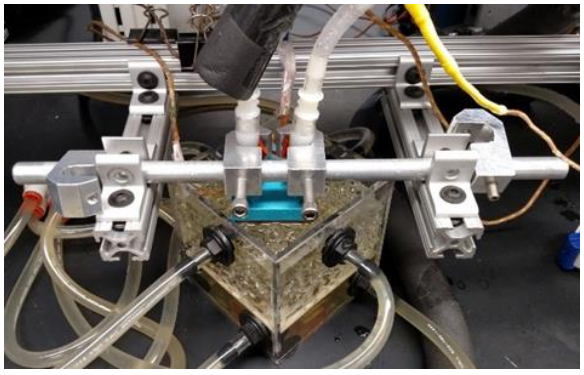
SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

Project 7 - Summer 2021

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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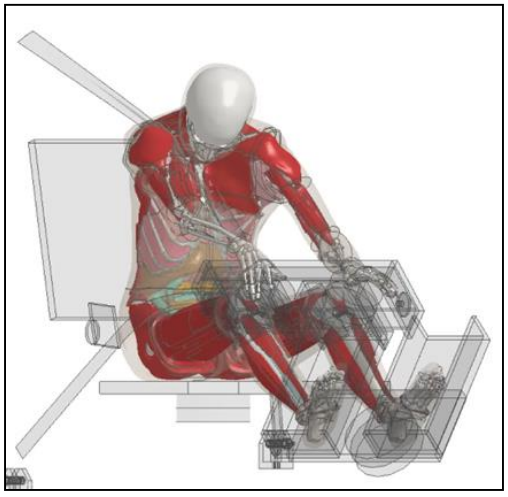
Project 8 - Summer 2021

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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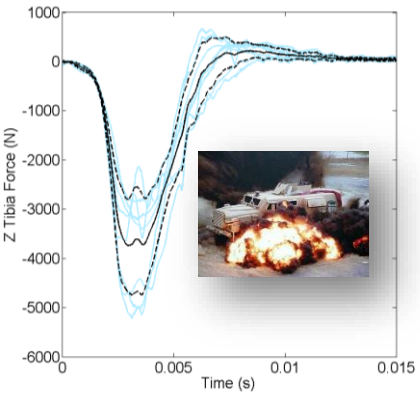
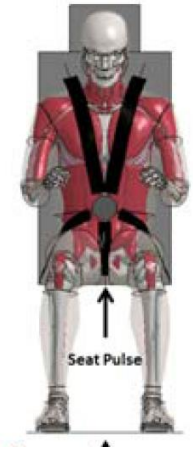
Project 9 - Summer 2021

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 2021

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

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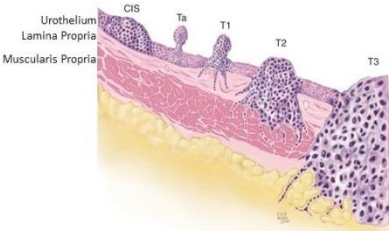
Project 11 - Summer 2021

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

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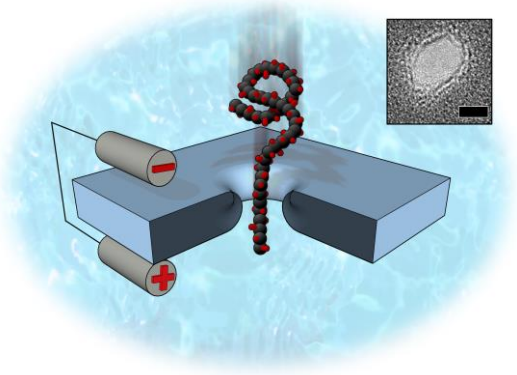
Project 12 - Summer 2021

Molecular Detection and Analysis of Trauma Bioindicators

Hyaluronan (or hyaluronic acid, HA) is a key linear sugar that is found in all physiological fluids and tissues, where variation in its composition can either result from or be a direct cause of disease emergence. While changes in net HA abundance in biofluids can be probed conventionally, this metric ignores a critical size-function relationship in which high- and low-molecular weight (MW) HA exhibit contrasting effects on inflammation, angiogenesis, cell motility, and more. Consequently, determination of both HA abundance *and* size distribution is essential. However, many important physiological systems contain small total amounts of HA and technologies for comprehensive assessment have critical limitations in sensitivity as well as challenges in dynamic range, cost, ease of implementation, and/or delivery of quantitative results.

In response, our laboratory has applied a molecular detection strategy using the solid-state nanopore platform, which is able to detect and size HA electrically and with tremendous sensitivity. Here, we will apply our assay to probe the HA content of plasma derived from trauma patients. As a central goal of this project, we aim to investigate HA MW as a bioindicator of outcomes for patients presenting with similar trauma severities.



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

- Biochemical extraction of hyaluronan from physiological samples
- Molecular detection with the solid-state nanopore platform
- Data analysis & reporting

Location: Wake Forest School of Medicine

Adam Hall, PhD

Assistant Professor, Biomedical Engineering
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https://thehalllab.org

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Project 13 - Summer 2021

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

Deputy Director of NNGN™ - the Wake Forest Center for Healthcare Innovation
Director of Digital Health Innovation
Associate Professor - Pediatric Hospital Medicine
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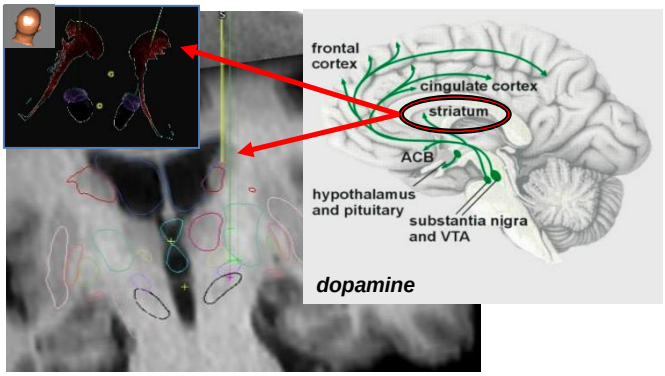
Project 14 - Summer 2021

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

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Assistant Professor, Neurosurgery
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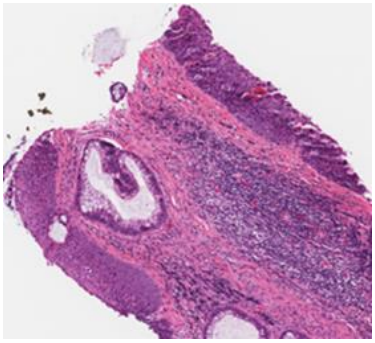
SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

Project 15 - Summer 2021

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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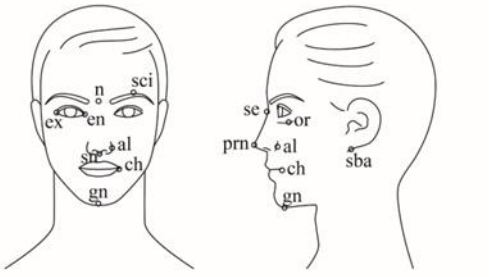
SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

Project 16 - Summer 2021

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

Khalid Niazi, PhD

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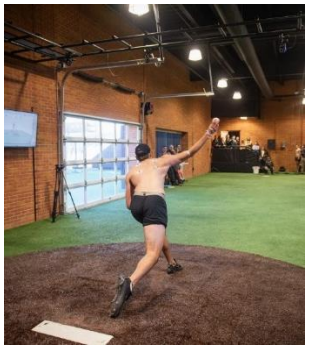
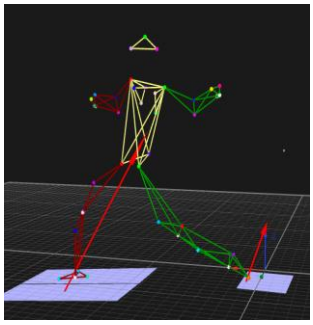
SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

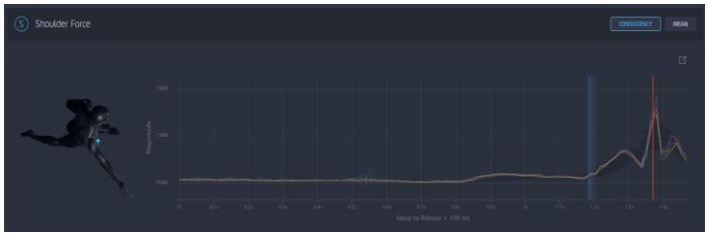
Project 17 - Summer 2021

Impact of Kinematics and Ball Weight on Shoulder and Elbow Stress During Weighted Ball Drills

The safety and efficacy of weighted ball drills for the baseball pitcher are highly debated. While some research has shown that throwing weighted balls improves pitching velocity, it is unknown how the kinematics and ball weight of specific weighted ball drills directly impact stress at the shoulder and elbow. This project involves collecting 3D motion capture data of weighted ball drills to investigate the impact of player specific kinematics and ball weight on the player's arm health.







The student will: 1) review literature on weighted ball drills and pitching biomechanics, 2) collect 3D motion capture data of players performing weighted ball drills, and 3) analyze the kinematics and ball weight influence on shoulder distraction force and elbow valgus torque. The student will apply skills they learn in human subjects' research, experimental design, data collection and processing, biomechanics and human movement, and statistical analysis to better understand the impact of weighted ball drills on the health of the pitchers' arm.

Location: Wake Forest School of Medicine

Kristen Nicholson, PhD

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SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

Project 18 - Summer 2021

Data Analysis Pipelines

Beyond the essential coded data elements in Electronic Medical Records (EMRs), additional metadata and free text data provide opportunities for better patient evaluation and care, if those elements can be easily incorporated into research data warehouses. In this project textual data can be mined with advanced targeted analysis as an injected step within the larger Natural Language Processing (NLP) concept extraction process. The first step in this pipeline is often to de-identify the text to remove Protected Health Information (PHI). The use of recurrent neural networks will be explored and compared with the results achieved through standard methods and tooling.

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, and ontological systems. Data characterization, cleaning, NLP, and visualization will be explored.

Required skills: Python programming
Prior experience with databases, statistics, and machine learning is helpful.

Location: Wake Forest School of Medicine

Brian Ostasiewski, MS

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Project 19 - Summer 2021

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

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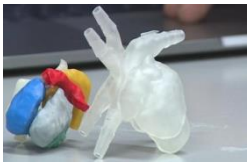
Project 20 - Summer 2021

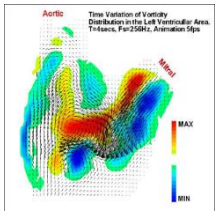
Effect of Improper Valve Sizing on Cardiac Performance

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

Olga Pierrakos, PhD

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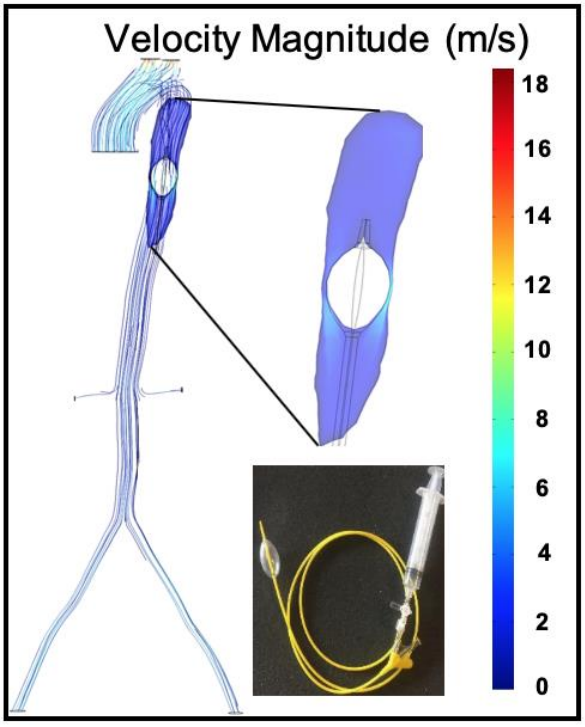
Project 21 - Summer 2021

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

Elaheh Rahbar, PhD

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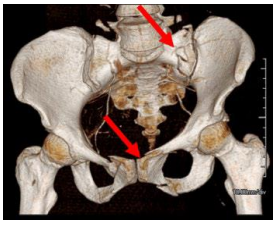
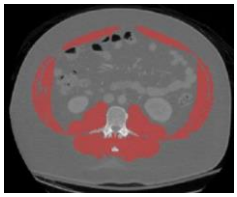
Project 22 - Summer 2021

Crash Injury Research and Engineering Network (CIREN)

CIREN is a research catalyst that can be used to conduct a wide range of motor vehicle trauma studies. It has been an ongoing project at WFUBMC since 2005.





The student will: 1) conduct detailed investigations of real-world motor vehicle crashes and determine mechanism and causation of occupant injuries to improve prevention, mitigation, and treatment of motor vehicle crashes, 2) collaborate and work closely with a broad range of medical specialties, including biomedical engineers, crash investigators, radiologists, orthopedic surgeons, and trauma surgeons, and 3) conduct finite element (FE) modeling reconstructions of CIREN crashes using the simplified GHBMC human body model of a simplified vehicle model providing kinematic visualizations and injury analyses to supplement our investigations.

Location: Wake Forest School of Medicine

Joel Stitzel, PhD

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Project 23 - Summer 2021

Head Impact Exposure Quantification and Mitigation in Motorsports

The Pilot testing of individualized mouthpiece deployment in motorsports involving injury risk assessment for the optimization of safety measures

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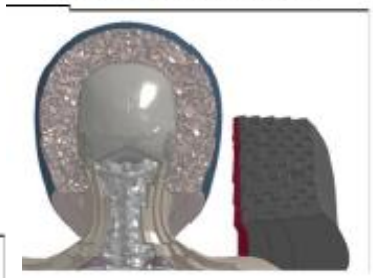
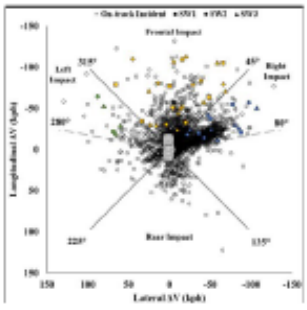
Driver FE Model

FE Simulation for Driver Safety Optimization



Example On-Track Impacts



The student will: 1) conduct analysis to quantify environmental and crash head kinematics, 2) utilize finite element (FE) modeling for injury risk assessment for drivers in crash scenarios, and, 3) FE simulation to optimize safety measures and driver comfort.

Location: Wake Forest School of Medicine

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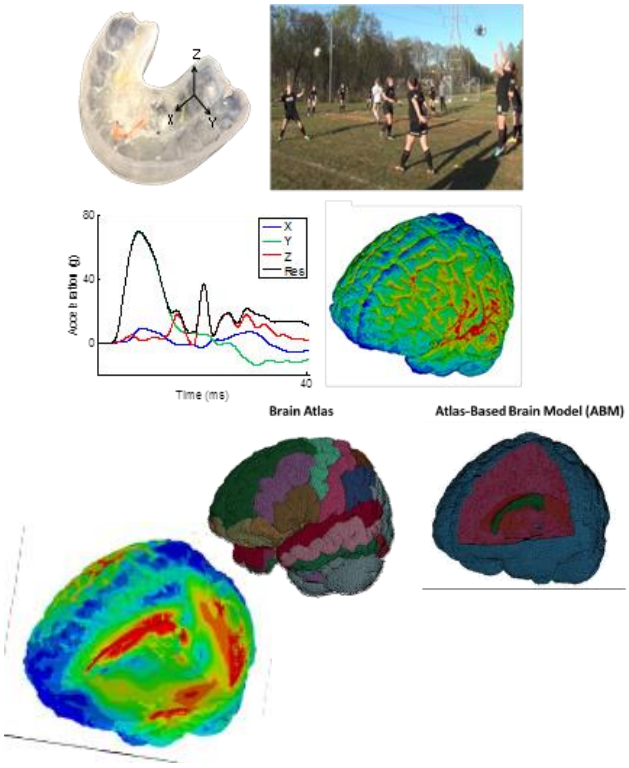
SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

Project 24 - Summer 2021

Subconcussive Head Impact Analysis using Instrumented Mouthpiece Data

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, gymnastics, 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) work on a 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

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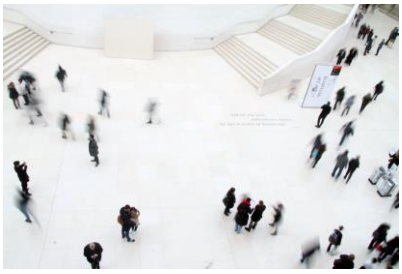
SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

Project 25 - Summer 2021

Clinical Trial Activation Prediction Models

The number of participants enrolled is directly correlated with the success of a study and consequently, low accrual for studies is a major barrier confronting the diagnostic and therapeutic developments with access and awareness among the most important factors. It is estimated that up to 50% of trials are not completed due to insufficient enrolments, which instigates the scientific delays and setbacks. We would like to apply machine learning methods that will predict clinical trials enrolment goals and correspondingly its success. Given the cost of activating a study at a site is approximately $50,000, identifying studies that have potential will have impact in biomedicine. The intern is expected to run the analysis and develop the models in coordination with the faculty.



Required skills: Programming in Python

Location: Wake Forest School of Medicine

Umit Topaloglu, PhD, FAMIA

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Project 26 - Summer 2021

Deep Learning Cancer Health Disparities

The overall survival rate of cancer patients has been significantly improved and cancer survivors face unique challenges. Our hypothesis is that: 1) local communities where cancer survivors reside have different socioeconomic, cultural, and ethical characteristics; and 2) such community-specific features are strongly associated with the lifestyles and the access to healthcare. The goal of this project is to better understand the relations between these factors and the risks of various aging-related clinical conditions through integrative **deep learning**. This project will use graph convolutional network (GCN) models to integrate the high-resolution geographical data, HER data, and the ACS data to comprehensively investigate the correlations between community-related characteristics and the health risks; to establish the roles of community health disparity in aging-related clinical challenges among cancer survivors and pave ways to precision management and delivery of healthcare for those at risk.

Required skills: Programming in Python

Location: Wake Forest School of Medicine

Umit Topaloglu, PhD, FAMIA

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Project 27 - Summer 2021

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 28 - Summer 2021

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 29 - Summer 2021

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 30 - Summer 2021

Tumor Tissue Biobank

WFBCCC Tumor Tissue Shared Resource is in the process of migrating to a new system that involves utilizing standard terminologies to represent tissue diagnosis and histology. The process involves extracting diagnosis from Tumor Registry as well as validating what is being extracted by our Natural Language Processing Engine after parsing pathology reports. The intern is expected to work with multiple teams to help process biobank data to be completed by querying, matching, analyzing reports.

Required skills: Programming in Python

Location: Wake Forest School of Medicine

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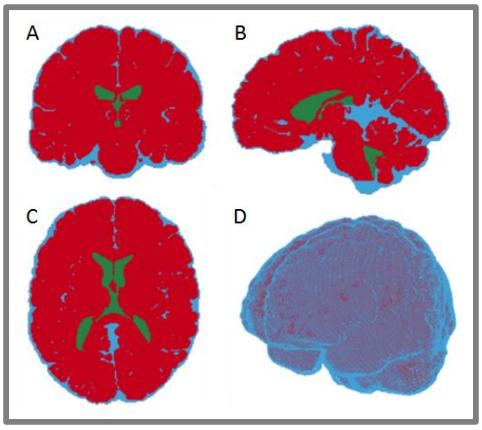
Project 31 - Summer 2021

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, MPH

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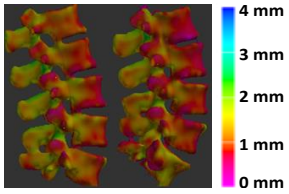
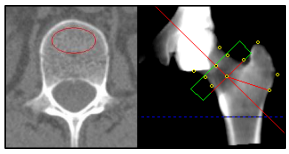
Project 32 - Summer 2021

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

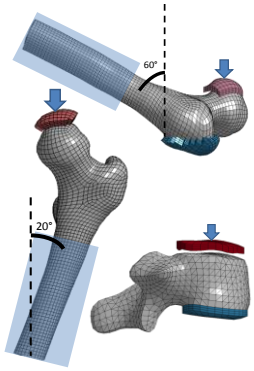
Weight loss is controversial in older adults due to its association with bone loss and increased fracture risk. This clinical trial aims to determine whether a high protein diet during and following weight loss will reduce loss of bone mineral density, bone thickness, and bone strength and decrease fat 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

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SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

Project 33 - Summer 2021

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

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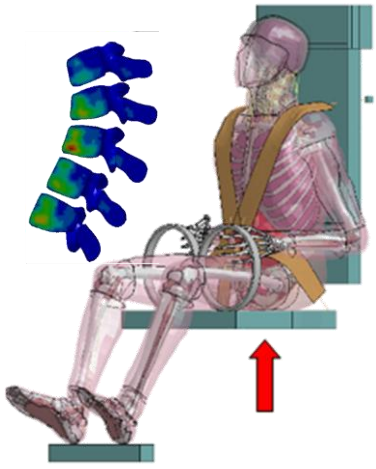
The student will: 1) review literature on astronaut musculoskeletal deconditioning and form a hypothesis to test the effect of spaceflight on a bone or muscle outcome, and 2) learn image segmentation and registration, BMD and cortical thickness algorithms, and FE modeling to analyze pre- to post-flight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



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VIRGINIA TECH | WAKE FOREST UNIVERSITY

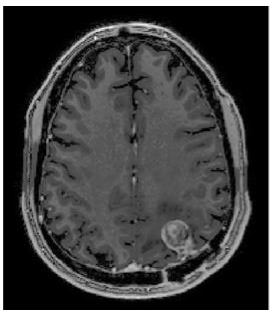
SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

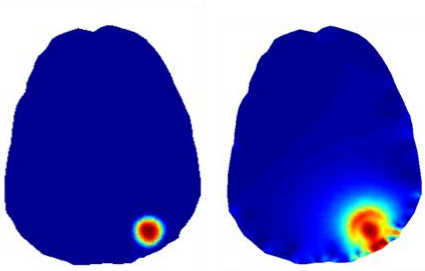
Project 34 - Summer 2021

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.





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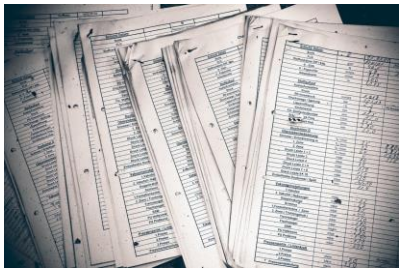
VIRGINIA TECH | WAKE FOREST UNIVERSITY

SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

Project 35 - Summer 2021

Diabetes Registry



The goal of this project is to create a research registry of diabetes patients derived from the Electronic Health Record (EHR) used by Wake Forest Baptist Health. The initial step in this process will involve the creation of an analytic dataset that will capture patient characteristics at a single snapshot in time. Potential tasks for the student could include:

- Writing and editing SQL code for the extraction and initial processing of data from the EHR database
- Writing and editing R script for cleaning data, transforming data, and creating curated variables for an analytic dataset.
- Literature searches to identify validated definitions for important variables / outcomes and to generate ideas for analyses that can be conducted by students during an upcoming course.
- Chart reviews of EHR data to adjudicate the research definitions
- Creating and editing a data dictionary and research manual for the registry
- Attending meetings with collaborators
- Assisting with the writing and editing of other documents or manuscripts.

Required skills: SQL, R

Location: Wake Forest School of Medicine

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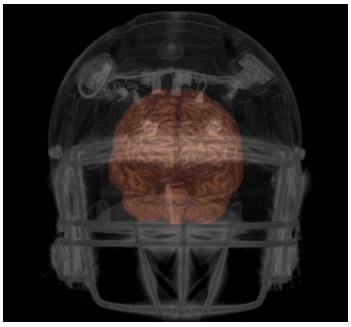
SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

Project 36 - Summer 2021

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
Clinical and Translational Sciences Institute (CTSI)
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VIRGINIA TECH | WAKE FOREST UNIVERSITY

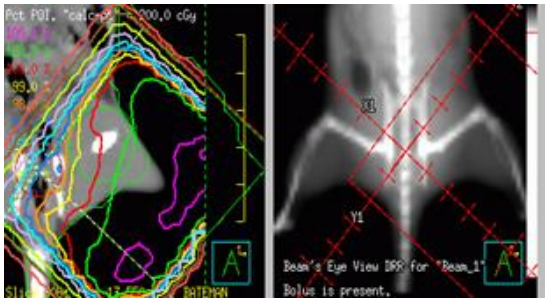
SCHOOL OF BIOMEDICAL ENGINEERING AND SCIENCES

Project 37 - Summer 2021

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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