Grant Roberts Website – <https://gsroberts1.github.io>

**My References:**

<https://github.com/gsroberts1/gsroberts1.github.io>

<https://academicpages.github.io/>

<https://archive.is/3TPas>

**Inspiration:**

Daniel Pimentel – <https://danielpimentel.github.io>

Phil Corrado – <https://pcorrado.github.io>; <https://stackmuncher.com/pcorrado>

Agah Karakuzu – <https://agahkarakuzu.github.io/#projects>

Violet Brown – <https://violetabrown.com>

Claus Wilke - <https://clauswilke.github.io/>

**Help:**

<https://jayrobwilliams.com/posts/2020/06/academic-website/>

<https://jayrobwilliams.com/posts/2020/08/website-content/>

<https://jayrobwilliams.com/posts/2020/09/jekyll-html>

**Layout Ideas:**

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# Homepage

**Links:**

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**Quick About:**

Specializing in clinical applications of phase-contrast MRI

**Biography (About):**

Grant is a PhD candidate in the department of [Medical Physics](https://www.medphysics.wisc.edu/) at the University of Wisconsin – Madison and is co-advised by [Oliver Wieben](https://www.medphysics.wisc.edu/blog/staff/wieben-oliver/), PhD and [Laura Eisenmenger](https://radiology.wisc.edu/profile/laura-eisenmenger-2119/), MD. His primary research focus is developing, validating, and applying [phase contrast MRI](https://en.wikipedia.org/wiki/Phase_contrast_magnetic_resonance_imaging) to study vascular health. He has experience in MRI reconstruction, signal processing, post-processing, data visualization, biostatistics.

Previously, he obtained a bachelor’s degree in [Radiological Science](https://healthprofessions.missouri.edu/radiologic-science/) in 2014 at the University of Missouri – Columbia. He then worked as an x-ray and CT technologist at the University of Missouri Hospital system for several years before deciding to pursue Medical Physics. In 2017, he obtained a bachelor’s degree in [Physics](https://cas.umkc.edu/areas-of-study/physics-and-astronomy/) from the University of Missouri – Kansas City being advised by [Dr. Tony Caruso](https://cas.umkc.edu/profiles/physics-and-astronomy/anthony-caruso.html) and mentored by [Dr. Fred Leibsle](https://cas.umkc.edu/profiles/physics-and-astronomy/fred-leibsle.html).

After graduation, he looks forward to continuing his career in MRI and data science in an industry position. Feel free to contact him with any questions or potential collaborations.

# Projects

**Current Projects:**

Aortic Pulse Wave Velocity (Code):

The effect of aging and cardiovascular disease plays an important role in progressive arterial stiffening that can be observed in older adults. When arteries become stiffer and less compliant, they cannot absorb pulsatile energy (systolic pressure) generated from the heart. This ultimately puts stress on smaller arteries (capillaries) that are not well suited for dissipating this energy. This can cause damage to peripheral organs, like the brain, kidneys, eyes, and hear. To measure arterial stiffness, one biomarker that has recently emerged is pulse wave velocity (PWV). PWV indirectly assesses vessel stiffness by measuring how fast blood pressure pulsations travel through larger arteries; stiffer arteries lead to faster traveling pressure waves. This method has become the gold-standard for non-invasively assessing arterial stiffness, which has proven to be an independent predictor of cardiovascular risk and mortality. Because larger, more elastic arteries have a more active role in absorbing pulse pressures, PWV is most often measured in the aorta and its immediate branches.

NOTE: A simple experiment to illustrate arterial PWV can be performed by placing one finger on your carotid artery near your neck and the other finger near your ankle where you can find a pulse. By feeling the pulse at both locations, you should notice a time delay in blood pulsations, which is exactly what PWV is. The difference in distances between the heart and these locations, as well as the stiffness of your vessels, determines this time delay.

Typically, arterial (aortic) PWV is measured by obtaining blood flow or pressure waveforms in the carotid and femoral arteries using tonometry, blood pressure cuffs, or ultrasound. Time delays/shifts (Δt) between these waveforms are calculated using mathematical methods. The faster the pulse pressure travels between these points, the shorter the time delay in the waveforms, which implies higher PWV, which again implies stiffer vessels. However, time delays are also a function of the distance, specifically, a vessel distance between the heart and each carotid/femoral measurement point (dcar/dfem). To account for this, we calculate *velocity* based on the difference in distance (Δd = dcar/dfem) between measurements (where aortic PWV = Δd/Δt). Distances are roughly estimated by measuring certain landmarks on the surface of the body using tape measures. While these approaches have been used successfully in many studies, the distance measurements are often prone to error because aorta morphology can vary from patient to patient.

More recently, MRI has been used to evaluate aortic PWV with the use of cardiac-gated 2D phase contrast (2DPC) techniques. Phase contrast MRI allows us to measure blood velocities and flow waveforms over the cardiac cycle and has been used to obtain flow waveforms in the aorta, similar to tonometry and ultrasound techniques. However, unlike more traditional methods, MRI can directly obtain angiographic images of the aorta to compute aortic distances directly and much more accurately determined. However, this approach is still challenging because it requires high temporal resolution to resolve sometimes subtle waveform time shifts. Higher temporal resolutions increase the overall scan time, which is especially problematic because these exams are done while the subject is holding their breath. This is because the aorta can move during respiration which can result in image artifacts. However, in some subjects such as elderly, diseased, or cognitively-impaired individuals, long (or even short) breath-holds may be difficult or impossible. Developing high temporal resolution, free-breathing PWV methodologies would thus be ideal.

In March 2021, I was awarded a 2-year F31 fellowship through the NIA ([F31AG071183](http://projectreporter.nih.gov/project_info_description.cfm?aid=10142190)). This research project is dedicated towards developing and validating a free-breathing, radial 2DPC simultaneous multi-slice (SMS) sequence with local low rank reconstructions to generate high temporal resolution images for accurate aortic PWV measurements. In addition, a robust post-processing analysis platform has been developed for automated, and repeatable PWV measures to enable analysis in large cohort studies, several of which are currently underway at the Wisconsin Alzheimer’s Disease Research Center (ADRC). The new imaging protocol will be used in a pilot study consisting of an AD cohort and an age- and sex-matched control group to collectively assess systemic cardiovascular health, macrovascular, and microvascular dynamics in the brain for the first time. This knowledge will help elucidate the role that the vascular system plays in pathogenesis and progression of AD.

Abstracts:

Code: [github.com/gsroberts1/PWV\_2DPC](https://github.com/gsroberts1/PWV_2DPC)

Normative Flow Study

*AD is commonly thought of as a brain-specific disease, however, recent evidence is beginning to suggest that cerebrovascular and cardiovascular risk factors may also play a critical role in the progression of AD. In early stages of AD, vascular changes occur before cognitive impairment and before detectable increases in CSF levels of amyloid-beta and tau proteins. Despite this, relatively little attention has been dedicated towards developing a comprehensive understanding of how both systemic cardiovascular and cerebrovascular disease contribute towards AD-related pathophysiology. In order to better understand this potential relationship, we need sensitive, non-invasive imaging methods to evaluate early-stage systemic cardiovascular changes.*

Abstracts:

NODDI and 4D Flow

White matter (WM) microstructural alterations have been shown to occur in Alzheimer’s disease (AD) and may be partially mediated by cerebrovascular disease (CVD). The objective of this study is to use neurite orientation dispersion and density imaging (NODDI) to assess differences in neurite density (NDI) and its relationship to measures of CVD from 4D flow MRI in cognitively normal (CN) and AD subjects. NODDI and 4D flow MRI demonstrate significant differences in white matter neurite density (NDI) in cognitively normal and Alzheimer’s disease subjects, as well as correlations between cerebral blood flow and NDI in cognitively normal subjects.

**Completed Projects:**

Chronic Mesenteric Ischemia

Chronic mesenteric ischemia (CMI) is a disease caused by inadequate blood flow to the intestines. This study investigated the use of 4D flow MRI to non-invasively assess the hemodynamics of mesenteric circulation in patients with CMI. Flow was measured in 9 vessels before and after meal challenges for 19 subjects suspected of CMI and 6 controls. Post-prandial flow increased significantly in the supraceliac aorta, superior mesenteric artery, superior mesenteric vein, and portal vein. The flow increase was drastically less in patients with CMI. This demonstrates the potential for 4D flow MRI in assisting the challenging diagnosis of CMI.

Virtual Injection (Code)

Streamlines are a particularly useful tool for visualizing 3D velocity fields, such as those generated from 4D flow MRI. In the brain, streamlines have been used for visualizing complex flow patterns in aneurysms, studying intracarotid plaques, and characterizing cerebrovascular malformations. However, both displacement artifacts (deterministic) and velocity noise (stochastic) inherently degrade the quality of streamlines. The purpose of this study was to try and improve 4D flow streamlines by integrating several correction methods and constraints to improve selective blood flow tracking and emulate “virtual injections”.

Code: [github.com/gsroberts1/Virtual-Injection](https://github.com/gsroberts1/Virtual-Injection)

Cranial 4D Flow Processing (QVT) (Code)

4D Flow MRI is a non-invasive imaging technique that enables the characterization of vascular anatomy and hemodynamics over a large imaging volume of interest. Detailed, multi-segmental analysis of the brain has been hindered by the complex cranial vasculature and long post processing times. Here we introduce an extension to a previously established 4D flow post processing tool1 that automatically segments and quantifies hemodynamic parameters in all vessel segments without the need for user interaction. This simplified post processing pipeline allows for robust and repeatable analysis and provides users the ability to easily visualize and quantify complex cranial 4D flow datasets.

Code: [github.com/gsroberts1/QVT](https://github.com/gsroberts1/QVT)

**Small Projects:**

Weight Loss Study

Background Phase Correction

Schrage Study (Code)

MR Elastography (MRE)

Eldridge Preterm Study

Gating Characterization (Code)

AJNR Peer-Review

Abdominal Review Paper 1

Abdominal Review Paper 2

Normal Portal Flow (Andrew)

FAST Neuroimaging Review

**Class Projects:**

Biofilm ML Segmentation

Accurate segmentation is important for quantifying structural and temporal characteristics of biofilm cultures and is of particular importance when monitoring a biofilm’s response to antibiotic treatment regimens. However, the large size of microscopy images, as well as the large number of images that may be needed for proper cell-tracking over multiple biofilm strains, warrant automated means of segmentation to expedite post-processing and increase segmentation repeatability. In this study, a fully convolutional neural network with U-Net architecture was trained to segment Pseudomonas Aeruginosa biofilm images using a total of 60 training and 10 validation datasets. This deep learning approach was compared to a “simple” manual segmentation using multi-vertex polygon ROI tracing. Both methods were compared to ground-truth biofilm images and quantitatively assessed using dice coefficients and modified Hausdorff distances to rate the efficacy of each method. Ground-truth images were obtained by producing an approximate mask using various morphological operations and by extensive manual fine-tuning of edges. Intra-observer repeatability of simple segmentation and ground-truth segmentation was assessed for 10 repeat datasets using intraclass correlation coefficients. It was found that ground-truth manual segmentation was extremely time-consuming, taking on average 23 minutes while simple segmentation took on average 1 minute. Deep learning segmentation resulted in fairly low accuracy, as measured by dice coefficients and Hausdorff distances. Further studies utilizing different frameworks, better computational resources, and augmented datasets are warranted to provide increased accuracy of automatic deep learning segmentation of biofilm images.

Compressed Sensing MRE

MR elastography (MRE) is a medical imaging technique that is particularly useful in quantifying mechanical properties of tissues by producing a stiffness map (elastogram). Recently, MRE has been applied to the brain to assess stiffness changes in various neurological conditions. Subsequently, compressive sensing (CS) is an image processing technique that aims to accurately reconstruct images from undersampled datasets, which can be used to shorten exam times or improve image quality. This paper aims to assess the feasibility of applying CS towards brain MRE exams. One fully-sampled brain MRE was acquired. K-space data was pseudo-randomly undersampled retrospectively and -wavelet regularized reconstruction was performed. CS reconstructed data were further reconstructed to produce MR elastograms. It was shown using various image quality metrics that undersampling of up to 50% produced accurate MR elastograms.

Region Growing Segmentation

Segmentation is a vital task in modern medical image processing that serves to reduce data analysis only to specific subregions that are of clinical interest. Advances in medical imaging technologies have provided the medical and scientific communities with larger datasets of ever-increasing image quality. There is an inherent need for robust segmentation methods that can extract clinically important information *automatically*, as opposed to performing time-consuming *manual* segmentation which is still done today in some clinical applications. The goal of this project was two-fold – (1) to recreate a multi-stage segmentation algorithm that combines both region-growing with a simplified Mumford-Shah (SMS) functional and (2) to develop a novel region-growing algorithm using the same formulation but with added flexibility in initialization conditions and adjustments to the cost function calculation, in hopes of increasing efficiency and accuracy.

# Publications

# Presentations

Invited

Cranial Hemodynamics Assessed with MRI: An Introduction with Relevance to AD – Part 1

Cranial Hemodynamics Assessed with MRI: An Introduction with Relevance to AD – Part 2

Panel Discussions

Moderator for Flow Imaging Scientific Session

Conference Presentations (Oral)

MRI Alphabet Soup

SMRA Power Pitch (Nantes)

SMRA Talk (Virtual)

ISMRM Talk (Vancouver)

ISMRM Talk (London)

Internal Presentations

Chronic mesenteric ischemia (MRI group)

MR elastography (MRI group)

NODDI-4D flow (MRI group)

PWV Tool (Wieben Group)

# Mentorship

Zach Bernhardt

Jennifer Fondakowski

Tarun Naren

Alma Spahic

Ruiming Chen

Daniel Seiter