**Real World Challenges of Software and Hardware**  
*Session Moderator: Afra Mashhadi, Computing Software and Systems*  
*MGH 295*  
*1:30 PM to 3:00 PM*

*Note: Titles in order of presentation.*

**Understanding Governance of Online Collaborative Projects**  
*Felicia Yan, Senior, Business Administration, Computer Science*  
*Mentor: Amy Zhang, Computer Science*

Open-source communities are central to facilitating the development of collaborative computing projects online. In any community, there are often policies that govern how the community functions, and as such communities become larger, projects have slowly seen more variety in their governance systems, making it no longer possible to just assume the governance structure of a project. The emergent practice of GOVERNANCE.md files in online collaborative code repositories such as GitHub works to close that gap by clearly defining the governing rules of what role contributors play and what guidelines they should be following. In this project, we developed a python script to scrape all the public GOVERNANCE.md files on GitHub in order to understand what the landscape of governance on GitHub looks like according to these files. Then, we analyze these files by creating data visualizations to compare different features of these files and characteristics of the community or repository (number of collaborators, creation date, number of edits to file, etc). This can then help develop answers to other key questions—how community governance files and models have changed over time, what aspects have changed and the driving factors/rational behind these trends, and whether or not the changes in these models are following any specific trends (such as becoming more democratized).

**Using a Microservice Architecture to Facilitate Big Data Analyses**  
*Xuweiyi Chen, Senior, Informatics, Applied & Computational Mathematical Sciences (Statistics)*  
*CoMotion Mary Gates Innovation Scholar*  
*Mentor: Ka Yee Yeung, School of Engineering and Technology, University of Washington Tacoma*  
*Mentor: Ling-Hong Hung*

The Biodepot-workflow-builder (Bwb) is a cloud-enabled platform that provides a customizable and interoperable application to enable accessible and reproducible analyses of biomedical data. Analytical workflows in biology typically consist of a sequence of computational tasks. Each widget in the Bwb represents a different module that performs a computational task. Users can use a drag-and-drop user interface to connect these graphical widgets in order to specify the flow of data and sequence of computational tasks. Currently, signals are generated by calling functions to modify states, and a Python GUI toolkit called PyQt is used to manage signals and connections between each module in Bwb. In this work, I developed a new extensible software engineering framework leveraging a chief and worker architecture to manage signals and connections in the specified sequence of computational tasks. My new framework uses microservices which arrange a task as a collection of services. Specifically, I develop a microservice framework using FastApi, a Python framework to develop REST API, and a PostgreSQL database which will save the history of connections, current signals and connections. FastApi will be responsible for communicating and coordinating the source service. This new framework is flexible, easy-to-maintain and modifiable, so that new services can be easily added to Bwb. For example, as future work, we will convert all the visualization code to a web-based service that will be managed by FastApi. By converting Bwb from a monolithic, static design to a dynamic microservice architecture, we make the platform more robust, maintainable and easily modifiable. Bwb can now adapt and scale to the increasing complexity of biomedical analyses and the increasing size of biomedical datasets.
Evaluating the Outcomes of Making PPE during a Healthcare Crisis
Jerry Cao, Senior, Applied Mathematics, Computer Science (Data Science)
   Levinson Emerging Scholar, Mary Gates Scholar, UW Honors Program
   Mentor: Jennifer Mankoff, Allen School of Computer Science & Engineering
   Mentor: Adriana Schulz, CSE

The NIH 3D Print Exchange is a public and open source repository for primarily 3D printable medical device designs with contributions from expert-amateur makers, engineers from industry and academia, and clinicians. In response to the COVID-19 pandemic, a collection was formed to foster creative submissions of low-cost, locally manufacturable personal protective equipment (PPE). To understand trends from this extraordinary occurrence of medical making, we performed a mixed-method analysis of this collection. We used a combination of qualitative data from a thematic analysis and quantitative data from web scraped details of over 600 submissions. From this analysis, we found a disconnect between the NIH’s intention for the platform and how it was used. Instead of generating a diverse array of designs, the submission requirements and rating designations led to a rapid convergence of the design space. In this presentation, I present our findings for what we believe resulted in this disconnect and provide suggestions for how to improve upon the repository’s design. This work contributes valuable insights into the outcomes of distributed, community-based medical making and how platforms can support regulated maker activities in high-risk domains such as healthcare. Furthermore, many of our recommendations could be applied to non-health focused maker repositories such as Thingiverse and Instructables.

Hardware-Software Codesign for Real-World Applications Using Custom Hardware Accelerators for Approximate Real Number Multiplication
Cameron James Norris, Senior, Electrical Engineering (Bothell)
   Mary Gates Scholar
   Mentor: Sunwoong Kim, Division of Engineering & Mathematics, University of Washington Bothell

The IEEE 754 standard, established in 1985, provides the most widely used formats for real number arithmetic. These formats use a floating radix point, and therefore they support a wide range of real numbers. However, these formats require greater computational complexity and hardware circuit area than the integer format. Many modern applications, such as multimedia signal processing and machine learning, are tolerant of approximate calculations. Thus, many custom hardware designs have been proposed for approximate arithmetic, especially for real number multiplication, that can calculate faster and with higher area efficiency at the cost of accuracy. This research is based on an existing approximate multiplier hardware architecture for 32-bit single-precision floating-point numbers. As this architecture uses an iterative approach, it has great advantages in reducing the circuit area. We extend the architecture to be used for the 64-bit double-precision floating-point number format and the recently devised Posit number format. The proposed approximate multiplier hardware designs are then applied to real-world applications, such as histogram stretching. Applications are developed on a hardware/software codesign platform, which has been optimized for cooperation between hardware and software components. In particular, real number multiplications are processed by the proposed hardware designs, and the rest is processed by an ARM processor on the platform.

Flipping the Script: Designing Systems to Support Blind Audio Description Scriptwriters
Lucy Jiang, Senior, Computer Science
   UW Honors Program
   Mentor: Richard Ladner, Computer Science & Engineering

Audio description (AD), an additional narration track that conveys essential visual information in a media work, is imperative for improving video accessibility for people who identify as blind or low vision (BLV). The AD creation process includes three steps: writing the script, recording the voiceover, and mixing the narration track with existing video audio. Despite being the primary beneficiaries, BLV individuals are limited in how they can contribute to AD authoring by technology inaccessibility and societal biases. The blind community and sighted allies advocate for including blind individuals in the AD creation pipeline, as their expert perspectives lead to high quality descriptions that prioritize the needs of the BLV community. To contribute to providing equal access to AD creation and to combat stigmas against blind AD writers, I am (1) designing and prototyping semi-automated AD features to make authoring more accessible to BLV creatives and (2) assessing the efficacy of question and answer systems in providing context for independent AD script authoring by BLV writers. Existing literature regarding AD does not address the needs of blind writers and the ways in which they interact with audio description writing systems. As there are currently very few blind writers in the AD industry, I am testing this system with 2 blind writers and at least 8 BLV people who are interested in writing AD. My findings so far show that current AD writing systems are inaccessible, and that BLV writers seek to have a detailed objective understanding of characters, background settings, and cross-frame actions prior to crafting artistic descriptions. Through this project, I am extending knowledge on BLV engagement with audio description creation and offering design considerations for AD writing systems to be more accessible for BLV writers who wish to independently write audio descriptions.
Plug-and-Play Platform for Measuring Computational Resources of Federated Learning on Android

Michael Cho, Senior, Computer Engineering (Bothell)
Mary Gates Scholar, McNair Scholar
Mentor: Afra Mashhadi, Computing Software and Systems, UWB

Machine learning is a powerful tool that allows us to use data to make predictions and decisions about the world, but it requires expensive centralized hardware and data, is prone to algorithmic biases, and has privacy concerns surrounding the use of required data. In contrast, Federated Learning (FL) allows users to collaboratively train a shared model under a central server while keeping personal data on their devices. This ability potentially addresses problems of traditional machine learning by using widely available mobile devices to increase accessibility to mainstream users and leverages decentralized user data and computational resources to train machine learning models more efficiently. However, this emerging field requires established processes for training and measuring the efficiency of FL models on edge devices. This research provides an inclusive framework to federatively train models on Android devices and analyze their computational and energy efficiency. On the mobile devices, I leveraged a terminal application to install dependencies and natively train FL models on the device. Then, I analyzed the device’s efficiency by measuring the computational, energy, and network resources through terminal applications. This flexible framework can deploy diverse machine learning models and datasets for training on Android devices. In preliminary experiments, I used this framework to measure efficiency for a PyTorch obstacle detection model and a Tensorflow abnormal heartbeat detection algorithm. These experiments showed that federatively training machine learning models on mobile phones makes efficient use of CPU, memory, and bandwidth, and it uses minimal energy consumption compared to centralized machine learning systems. With little to no examples of FL on Android devices, this framework provides a novel plug-and-play solution for native FL on mobile devices. Applications of this research will also demonstrate using FL techniques to address topics of accessibility, privacy, algorithmic bias, and hardware limitations for the machine learning domain.

Monitoring Central Venous Pressure Using Smartphone Videos

Hannah Yoonkyu Lee, Senior, Applied Mathematics, Computer Science
UW Honors Program
Mentor: Shwetak Patel, Computer Science & Engineering
Mentor: Jason Hoffman, Computer Science and Engineering

Heart failure (HF) is a leading cause of hospitalizations in the United States, with nearly 900,000 hospitalizations annually and more than 500,000 new diagnoses each year. Many HF patients suffer from elevated venous pressure due to a failure to adjust medications when necessary, causing nearly 1 in 4 HF patients to be readmitted within 30 days of discharge. However, to monitor venous pressure, physicians currently use Central Venous Pressure (CVP), which must be measured in-clinic. We propose a low-cost, remote method of estimating CVP in-home utilizing a standard smartphone camera with the goal of preventing unnecessary readmissions. By taking daily, noninvasive measurements of CVP, patients may be provided with an early indication to adjust medications to maintain safe venous pressure levels, both improving their quality of life and lowering the cost of care. To measure CVP using a smartphone camera, our research team is developing a mobile application to capture video recordings of a subject’s neck. These recordings are then analyzed using our signal processing pipeline, which aims to filter for venular pulsation resulting from changes in pressure due to respiration. We expect to find varying amplitudes of light captured at different elevations of the body, and based on these amplitudes, we theorize that we can determine levels of CVP. These CVP estimations will be correlated with CVP measurements taken using current standard practices by physicians. We anticipate that in a future study, HF patients may utilize this monitoring tool to compare in-clinic CVP measurements during hospitalizations and follow-up visits to our estimated CVP measurements.