

## 1. Exploring Consistency Semantics for Distributed Systems in Serverless Environments

**Dr. Ji-Yong Shin, Huiyu He**

Distributed systems are collections of computing nodes that work coherently. Powerful, reliable, scalable, and high available distributed systems have been heavily used in cloud computing, high performance computing, crypto currency and so on. The network connecting nodes and nodes themselves can be slow and can fail, which brings consistency issues in the systems. And different consistency protocols, strong or weak, consistent-oriented or performance-oriented, have been proposed and used in real systems. However, users of distributed systems in serverless environments tend to use modules with different semantics together, the effects of which are not well-studied. In this summer research project, multiple distributed systems with different semantics have been built, and experiments have been designed to measure the abnormalities. The results of this study can provide insights of how to combine modules with different schematics to build more efficient distributed systems.

## 2. The Microaggression Games Project

**Dr. Alexandra To, Heng Su, Xinyu Hou, Doxa Asibey**

The Microaggression Games Project is an extension to Professor Alexandra To's previous research on interactive fiction that facilitates conversations about the sensitive topic of microaggressions. Each student developed a transformational game on Twine, an open-source tool for telling interactive and nonlinear stories.

In our work we incorporate Critical Race Theory, Intersectionality, and Queer Theory as well as learnings from activist and organizing spaces to study and design technologies and games to empower and uplift people of color. We use primarily qualitative and design research methods to curate counternarratives and create counterspace.

Heng Su developed a role-playing game called Golden Age and it is about Chinese and Chinese Americans' experiences in the 1800s. Two major storylines on California golden rush and being a nursemaid in a Christian family presents counter-stereotypical content to educate players about the Chinese Americans' integration and contribution to the American community, as part of the efforts to overcome the anti-Asian sentiment

Doxa Asibey developed a transformational game called They Didn't Mean that, which explores a specific type of microaggression. This project aims to educate and facilitate conversations about racial microaggressions through a fictional interactive game that follows a racial minority undergraduate student and their experience with microaggression.

Xinyu Hou's game is named What's on Your Mind and it is about how to become an ally to someone experiencing microaggressions. The central Transformation to expect from this game is knowledge & supporting transformations on disposition & behavior.

As the next step, students will take advantage of a thesis option and design surveys for players to finish before and after playing the game gauging the players' cognitive pattern on the subject of the game and educational effects of the game.

## 3. Verifying Neural Network for Systems

**Dr. Cheng Tan, Akwarandu Ugo Nwachuku**

These days neural networks tend to be used as a black box in safety critical systems. However, regardless of training and test performance, neural networks are susceptible to produce unexpected results due to slight perturbations in the input. An unexpected output from a neural network used in a safety critical system can be dangerous. This research presents neural network verification: a tool or process adopted to verify the behavior of a neural network, with the use of reachability and

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approximation methods. This research focuses on a congestion control safety critical system: Aurora, from “A Deep Reinforcement Learning Perspective on Internet Congestion Control”. We investigate a set of specifications and expectations for Aurora, in an attempt to verify its performance. We discover that the underlying neural network in Aurora has unexpected behaviour in a number of network traffic scenarios. Results from our study are included in a benchmark suite for the neural network and systems community. The ultimate goal being to bridge a gap between the neural network and systems community.

#### **4. Predicting Cybersickness Ratings in Stereoscopic Videos using 2D Convolutional Neural Networks** ***Dr. Caglar Yildirim, Kavya Gajjar, Dyuthi Vinod***

Cybersickness refers to unpleasant side effects such as nausea and dizziness invoked as a result of exposure to certain virtual reality (VR) experiences. With the advent of 360-degree cameras, more individuals immerse themselves into this world. Therefore, it becomes important to address the problem of cybersickness induced due to these videos. We proposed a 2D CNN model to predict the degree of cybersickness in 360-degree stereoscopic videos. This was done with the help of two feature maps, optical flow and saliency. We used a dataset containing 19 videos, each 60s long, from which 120 frames were extracted to use as input to the CNN model. Pixel shifting, a data augmentation method, was also implemented to increase the number of data points. After thorough analysis, optical flow with data augmentation proved to give the best result. Given the limited size of the dataset, the results provide a first step in addressing this important issue in virtual environments.

#### **5. BERNICE and SAM: New Metrics for Evaluation of Cohesion and Meaning Preservation in Automatic Text Simplification**

***Dr. Raman Chandrasekar, Heather Fryling, Haoyu He, Michael Manzon***

Automatic text simplification (ATS) transforms text such that it becomes easier to read, comprehend, and process. In lexical simplification simpler synonyms are substituted for complicated words, and in syntactic simplification, complex sentences are split into simpler sentences while preserving meaning. ATS is typically a mixture of both.

While ATS has taken great strides in recent years, simplified text does not always preserve the cohesiveness and meaning of the original text. We propose the first metrics to directly measure the preservation of sentence-to-sentence cohesion and meaning during automatic simplification, using state-of-the-art transformer technology. BERNICE (BERt Nsp Inference for Cohesion Evaluation) compares sentence-to-sentence cohesion between source and simplified text. SAM (Sentence-level question-Answering as Meaning-preservation metric) measures meaning preservation by comparing simulated reading comprehension on original and simplified text.

We have coded and integrated both metrics with the Easier Automatic Sentence Simplification Evaluation (EASSE) package for convenience. We additionally provide a web app to visualize BERNICE and SAM results. We believe direct measurements of cohesion and meaning preservation will empower researchers to develop improved ATS systems.

#### **6. Co-Designing a More Supportive IDE**

***Dr. Abigail Evans, Zihan Wang, Jieren Liu, Mingming Zheng***

Most popular IDEs provide useful features such as syntax error detection and debugging tools to assist users in improving codes. However, these features are designed for more experienced programmers and will not provide certain help regarding further coding improvement. This research project aims to use participatory design methods to explore how those features could be repurposed to help novice programmers identify misconceptions and improve their understanding of programming fundamentals

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quickly and independently. We propose a program that will detect errors and find improvement potentials to assist programmers in gaining more helpful experience from regular practices.

## 7. Robust Federated Learning in Adversarial Settings

**Dr. Tamara Bonaci, Kicho Yu, Madeleine van Zuylen**

In recent years, the need for privacy-preserving machine learning has increased rapidly. This need is predominantly driven by three distinctive groups of shareholders: legislators and the regulatory sector, companies and commercial space, and private citizens and civil liberties organizations.

Federated learning is emerging as one of the leading branches of privacy-preserving machine learning. It is a novel and promising machine learning approach that allows for a learning model to be trained in a distributed manner. Each node (entity) in this distributed system holds their own private training dataset, and it relies on a centralized node to aggregate training updates, and release the complete trained model.

While federated learning is seen as a promising approach to improving and achieving privacy of data and models, its distributed nature introduces a novel set of problems that do not exist in traditional machine learning models. Namely, a federated learning system operating in an adversarial setting is prone to a variety of security and privacy attacks, originating from the distributed fashion of the system itself. While researchers in the federated learning space often consider the robustness of the proposed algorithms, other security and privacy attacks have gotten little attention thus far. We consider a federated learning approach in an adversarial setting, where an attacker has a way to compromise a subset of nodes to execute their malicious intent. Federated learning has the potential to be secure and privacy preserving in adversarial environments.

## 8. Performance Debugger

**Dr. Mike Shah, Gail Renee Pinto**

Interactive debuggers are tools that allow users to explore the state of a program during run-time. The ability to query the state of objects, variables, memory, and the call stack are standard features in an interactive debugger. There exist tools such as profilers (e.g. perf) for giving a general overview of where programs are slow, but often these tools do not measure that right granularity of where inefficiencies exist. Most debuggers do not incorporate ways to step through a program and query the performance of the program at run-time. This research proposes an interactive performance debugger which can set breakpoints to measure performance metrics such as CPU cycles, time elapsed, and cache misses in a running program, just like an interactive debugger.

## 9. Quadratic Polynomial Correlation Bounds with MOD3

**Dr. Manu Viola, Brenden Collins**

We aim to show that the correlation between quadratic polynomials mod 2 and the MOD3 function is maximized when the polynomials are symmetric. Our initial approach showed that the class of symmetric polynomials achieves higher correlation values than several other well-defined classes of polynomials (e.g. block-symmetric or switch-symmetric polynomials). We are currently working to finalize a more general proof demonstrating that symmetric quadratic polynomials mod 2 achieve higher correlation with the MOD3 function than any arbitrary quadratic polynomial mod 2.

## 10. Exploring the Performance and Scalability of Cloud-based Infrastructure Platform

**Dr. Ian Gorton, Vijaya Teja Rayavarapu, Shireen Firdoz, Rahul Pandey, Aakash Darshak Shah, Donghui Zhang**

Distributed systems deployed on cloud platforms commonly exploit powerful services that make it possible to build high performance and massively scalable systems. These services are highly

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configurable, and their performance can be tuned through multiple configuration parameters. As these parameters are not independent, it is difficult to predict the effects of changes a priori, making experimentation a necessity to achieve the desired performance at lowest cost. In this project we are using parameter studies to explore the effects of parameter tuning on application behaviours. The eventual aim is to investigate if response surfaces created from parameter studies are (1) effective in guiding engineers to find near-optimal parameter settings, and (2) predictive of the behaviour of configurations not tested during experimentation.

## 11. List Curation

***Dr. John Alexis Guerra Gómez, Jinqian Pan***

People frequently search the Internet for a range of items in order to locate the resources they require in their everyday life. For example, they search Kelley Blue Book for used vehicles and Amazon for products they want to buy. These sites, on the other hand, only display the most popular or most purchased things. These things aren't always what users want. Rather than browsing through someone else's preferences, users may wish to explore some facts that they are genuinely interested in to help them make judgments. We wanted to create a tool that would assist users in finding the data they were looking for. Existing solutions often sorted by the attribute or attributes chosen by the user, but this ignored the importance of other aspects, thus it wasn't exactly what we wanted. In our opinion, the best way to identify data that people are interested in is to infer and find data in the database based on their browsing and notes. Data Loader, Sorter, Filterer, Summarizer, Annotator, Seener, Lister, Detailer, and Recommender are the nine modules we want in the tool. Filterer will be improved in the future to help users filter information, Annotator will be improved to capture notes, Detailer will be improved to overview data, and Recommender will be improved to recommend data to users.

## 12. Object Detection for Airplane Inspection

***Dr. Michal Aibin, Ruchi Bhavsar, Thinh Lam, Mino Reyes***

Safety inspections are essential in maintaining an airworthy fleet. Currently, frequent regular safety checks require multiple hours of human inspection, with an imperfect accuracy rate. We investigated whether the inspection process could be automated by training YOLOv4, an object detection tool, to recognize six categories of flaws on aircraft exteriors: dents, cracks, missing screws, corrosion/rust, peeling paint, and other. We found that the model, once trained, performs less well than a human aircraft engineer and likely will require adjustment.

## 13. Readalongs Project

***Dr. Michael Running Wolf, Fangyuan Huang, Luyi Xiao***

Many unique indigenous languages are dying and eagerly need help to survive. Readalongs is developed under this context to support and help communities with endangered languages.

In essence, Readalongs is an audio-text alignment tool, designed and maintained by the National Research Council Canada (NRCC) Team. It aligns the input text dialogue with the corresponding audio and forms an interactive presentation. This tool is especially useful for new generations in indigenous communities to learn their mother tongue.

In this project, we worked with the NRCC team to make Readalongs more accessible and user-friendly. The existing Readalongs tool requires users to have many technology backgrounds, such as understanding how to spin up a docker container, and start a local http server with python from the terminal. Unfortunately, most users are teachers who have very limited knowledge in Linux systems. On top of that, many users live in areas with limited access to the internet.

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As a result, we propose this solution where we extracted the existing code, designed a new GUI interface, and optimized the workflow. Users no longer need any Linux knowledge to run the tool. Our solution also provides a one-stop experience for users (compared to the old method, users may need to run four separate command lines to perform a task.) Users would be able to perform basic tasks within clicks without needing help from technicians.