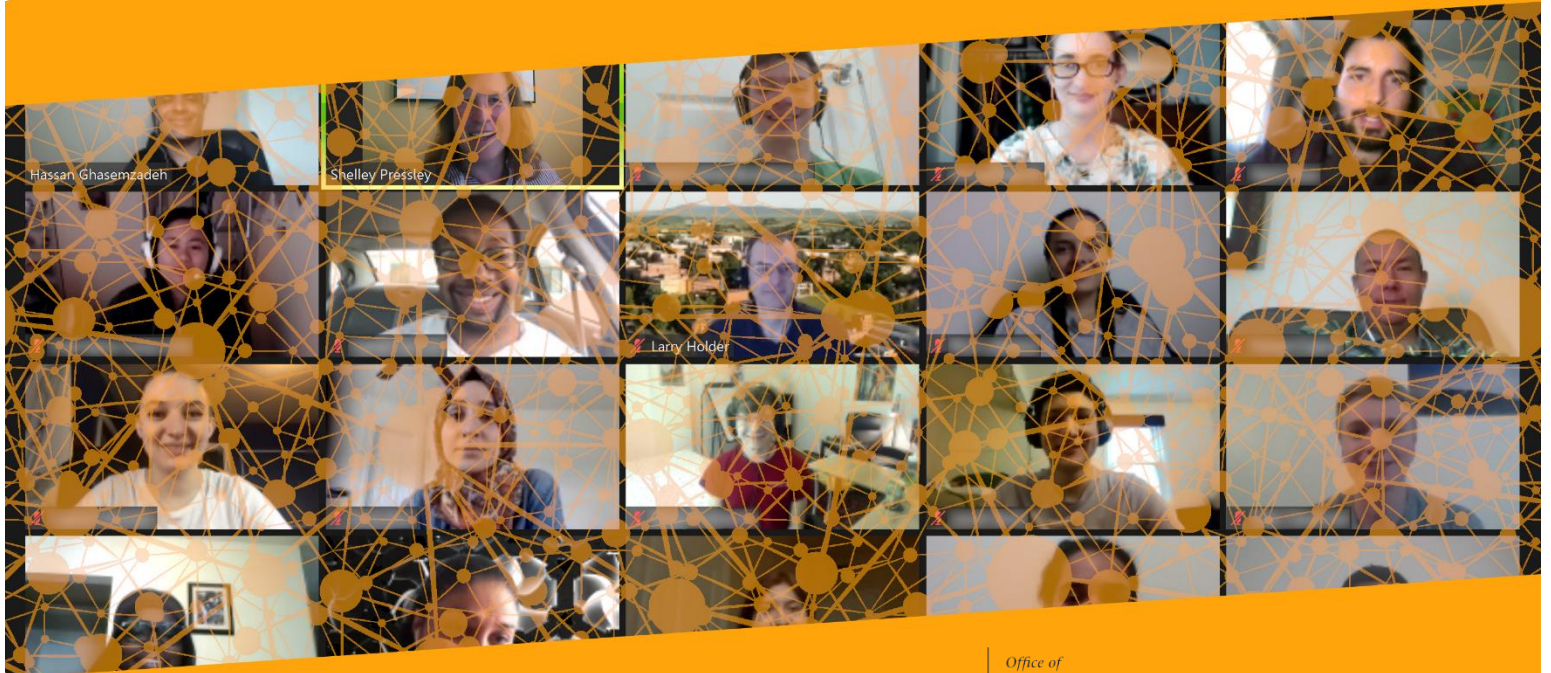# WASHINGTON STATE UNIVERSITY

SUMMER UNDERGRADUATE RESEARCH
ABSTRACT BOOK 2020

Office of
Undergraduate Research
WASHINGTON STATE UNIVERSITY

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Letter from Our Assistant Vice Provost

Welcome to WSU Summer Undergraduate Research!

Each of the past many years, Washington State University has had the pleasure of welcoming exceptional students from across the nation to join us for summer undergraduate research. But in 2020, the COVID-19 international pandemic turned our usual summer plans upside down in short order. We are pleased to say that thanks to some enterprising and innovative faculty and students, summer research at WSU did go on—virtually. Some of their work is shared in this abstract book.

During mid spring semester, the dynamics of ongoing research by WSU students with their mentors changed when the university followed "shelter in place" orders and in-person classes moved immediately online and laboratories had new rules. That was about the time when a dozen research programs were reviewing applications from would-be summer researchers. Two programs decided to move forward, and 16 students from 15 universities decided to join with us via an online format.

Both of those programs are funded by National Science Foundation (NSF) Research Experience for Undergraduates (REU) grants, and both are in the Voiland College of Engineering and Architecture's School of Electrical Engineering and Computer Science. They are: "Multidisciplinary Undergraduate Research Training in Wearable Computing," led by Hassan Ghasemzadeh, associate professor in the School of Electrical Engineering and Computer Science (EECS); and, "Undergraduate Research in Smart Environments," led by Larry Holder, professor in EECS. In addition to these principal investigators, several faculty members serve as mentors, supported by graduate assistants.

As the 10-week summer REU's were wrapping up, we interviewed the PI's, mentors, and several students who had taken part in the virtual research over the course of the summer; please read that story in this book. They mentioned some challenges of collaborating on research in an online manner, but by all accounts, the experiences—while novel, for sure—were rich, meaningful, and helped to advance the topics under investigation. Many students said they missed the chance to work, network, and, yes, even play in person in Pullman as part of their research team, but they also appreciated the helpfulness and enthusiasm the WSU researchers extended, making the very most of the situation.

The NSF program director praised the WSU faculty and the student researchers, saying, "The REU's that proceeded virtually are made up of exceptional people in this extraordinary year. They *did* it, and the NSF and I are grateful."

We, in the Office of Undergraduate Research, also applaud this year's summer programs and researchers. And, while we and our amazing university community could not welcome them in person in true Cougar fashion, we supported and are proud of their accomplishments. We are honored to share their work and results in this abstract book.

Sincerely,

Mary Sánchez Lanier
Assistant Vice Provost

Summer Research 2020 News Story

Story Published on July 30, 2020 in the .

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Friday public research presentations online

Two WSU NSF-sponsored undergraduate summer research programs move ahead despite pandemic challenges

PULLMAN, Wash.—Despite in-person restrictions necessitated by the COVID-19 pandemic, two National Science Foundation (NSF)-sponsored research programs for undergraduates went forward at WSU this summer and welcomed 16 students from 15 universities—online.

Both are in the Voiland College of Engineering and Architecture's School of Electrical Engineering and Computer Science. They are: "Multidisciplinary Undergraduate Research Training in Wearable Computing," led by Hassan Ghasemzadeh, associate professor; and, "Undergraduate Research in Smart Environments," led by Larry Holder, professor in addition to these principal investigators, several faculty serve as mentors, supported by graduate assistants.

"For the past decade or so, WSU has hosted a number of NSF Research Experience for Undergraduates (REU) programs, and hundreds of successful applicants have come to our university in Pullman to participate in faculty-mentored science, technology, engineering, and mathematics (STEM) investigations in our labs," said Shelley Pressley. She is director of the Office of Undergraduate Research, part of the Division of Academic Engagement and Student Achievement (DAESA) in the provost's office.

"Because of COVID-19, in-person teaching and learning was curtailed this summer. We wondered if, for the first time, we would not welcome REU students. But then, two out of a dozen summer programs stepped forward, adjusted protocols, and went forward with their projects, moving everything to a virtual format. We've been excited to see how they would go."

REU's draw high NSF praise

"It took a lot of courage and commitment for PI's and mentors and their teams to make things happen virtually," said Wendy Nilsen, program director for health and computing space in the NSF Computing, Information Science, and Engineering Directorate.

Of the 95 REU sites in her directorate, just 17—including WSU's two—said they wanted to move ahead and conduct the 10-week REU's virtually.

"They knew that many students applying to participate may never have gotten another chance to do research, work in teams with peers from many colleges, or add a prestigious NSF-sponsored experience to their resume.

"The REU's that proceeded virtually are made up of exceptional people in this extraordinary year. They *did* it, and the NSF and I are grateful."

Not a typical year

In a more normal year, around 100 REU students come to Pullman to be in around 12 REU's, live together in housing near campus, work daily in labs, attend brownbag lunches featuring guest speakers, partner with their mentors and teams, have BBQs and bike on country trails, and present research posters publicly. Each would receive roughly $5,000 for their efforts and to cover costs.

In summer 2020, students in the two REU's are working on projects assigned to them by their mentors and getting to know their teammates and attending presentations via video conferencing tools such as Zoom. Their funding may have helped cover special expenses, such as home technology setups.

Smart Environments

Holder's REU is in its fifth year, with students performing tasks related to smart environments including artificial intelligence, machine learning, data mining, high-performance computing, pervasive computing, networking, distributed systems, health, medicine, psychology, gerontechnology, and energy sustainability. After the experience, many students have been listed as co-authors in published articles, thanks to their research.

This year, from more than 100 applicants, Holder and mentors made offers to 10, and eight accepted.

"We could have said 'sorry' and wasted all those evaluations and given them bad news," said Holder, "but then the programs may not have moved forward as well, and it would have been a bad deal for the students. We're glad we contacted the NSF to say we'd decided to proceed remotely."

One of Holder's mentees is Filipp Shelobolin, a statistics and machine learning major at Carnegie Mellon University in Pittsburgh. He's analyzed data involving COVID-19, airlines, and virus transmission rates to understand and predict how the virus might move from place to place.

"I know I'm making a difference," he said, "and this REU experience has also led me to consider going to graduate school, which I hadn't thought much about before."

Another Holder mentee, Luisiana Dominguez, is a computer science junior at Lehman College in Manhattan, N.Y. Her summer task is to work with an AI system to perform tasks and play games and benchmark it against other systems to see how smart it actually is.

She has found that establishing routines and time management have made the online research environment easy and enjoyable overall.

"I'll likely have to work from home sometime in my career, so this REU has helped me see how that would go plus it's been a once-in-a-lifetime opportunity," she said. "I think I would definitely consider WSU for graduate studies."

Wearable computing

Ghasemzadeh's REU is in the second of its three years, focusing mainly on project topics including wearable computing and healthcare. With much data already gathered, it was possible to design analysis projects so students could work virtually.

"We had to make some adjustments but it's really been pretty easy and certainly interesting from the start," Ghasemzadeh said.

Computer science Ph.D. student and teaching assistant Samir Sbai assisted 2019 REU's and this spring helped faculty "spitball how to re-create what would normally be an in-person situation into a virtual one while maintaining value for every student. Even the process to do that was new, because the mentors themselves had to collaborate online since we weren't physically at work at the university."

Good experiences abound

Wearable computing mentor and architecture assistant professor Mona Ghandi's project Ainvolves biological data processing collected from smart wearables to detect a user's emotion and influence home environments to improve the user's mental health.

 "My REU students and my research team use Slack channels to stay in touch, email often, and meet online weekly. It was a great productive experience and They are motivated to learn and participate. I'd definitely do virtual research with students again."

One of her three students, Joshua Okamoto, future software engineer and current Univ. of California-Berkeley electrical engineering and computer science student, had no research experience before the REU. Over summer, he's used new technologies, designed web pages, and learned about machine learning.

"The whole experience has been pretty cool."

Charmaine "Cid" Canja, a first-generation student pursuing electrical engineering and computer engineering at Seattle's Bellevue College, worked with Robert Catena, REU mentor and assistant professor of kinesiology. She's learning new software to develop an app to help pregnant women maintain good physical balance.

Canja said the REU experience is boosting her self-confidence and has strengthened her resolve to change career fields—she has a nursing degree from the Philippines.

"WSU's provided me with a big-time good experience. It wasn't anything like I'd imagined, scary or high-stress. The people are so friendly and encouraging."

Sbai looks to the future. "If this is a new normal for students seeking STEM research in REU's, I'm encouraged. I've seen it work--it can be done. It just requires a little more planning and resilience on everyone's part. Overall, I've been impressed with every team. It's been inspiring."

Virtual presentations Friday

On Friday, July 31, both sets of REU students will make final presentations from 10 a.m. till noon, with short descriptions of their work and results. Contact Holder at holder@wsu.edu and Sbai at samir.sbai@wsu.edu for information.

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Abstracts

Biomechanics Mobile App: Measuring Balance with Smartphone Sensors

Presented by: Charmaine Canja

Program: Multidisciplinary Undergraduate Research Training in Wearable Computing
Co-authors: Yonas Abraha, Caelum Noonan, Ramesh Kumar Sah, Robert Catena
Home Institution, Major, Class Standing: Bellevue College, Computer Science, and Freshman

Falls are a commonplace occurrence that can potentially have severe consequences such as a traumatic brain injury or a fracture. Our goal is to create a convenient and wide-scale research tool that measures a person's balance, so that promotive and preventive measures may be developed especially for various populations susceptible to falls. There are more reliable, in-depth research tools available, but they are limited to an in-lab setting with drawbacks associated with costs, resources, accessibility, and compliance. Our mobile app approach takes advantage of the ubiquity of smartphones and could largely mitigate these problems.

Our app provides researchers a platform to deploy large sample remote testing of any variables measurable by inertial sensors such as an accelerometer, gyroscope, and magnetometer present in a smartphone. By using a login interface, our app is able to suit the need of both a researcher and a subject. A researcher can draft custom tests which they can deploy among individuals or groups that are in the userbase. A researcher can deploy a set of instructions that appear on the screen. They are also able to customize trials, blocks of trials, and testing protocols for multiple projects, and can collect sensor data for follow-up analysis. Users also have the option of creating their own custom test, with the option of sharing the results in a CSV format.

The next steps are reliability and validity testing in an in-lab setting, including analysis of how it compares to in-depth methods such as motion capture cameras. Ease of access for both researcher and end user interface will be evaluated through user testing methods.

Adversarial Attacks on Deep Models for Audio Data

Presented by: Tyler Cleveland

Program: Multidisciplinary Undergraduate Research Training in Wearable Computing
Co-authors: Taha Belkhouja, Janardhan Rao Doppa
Home Institution, Major, Class Standing: Washington State University, Computer Science, and Senior

Audio classification is a task that enables a range of real-world applications from music genre labeling to environmental sound classification in security systems. Deep neural networks (DNNs) are commonly employed for this task because of their ability to extract features from the raw audio data, resulting in higher accuracy without manual feature engineering. In recent years, DNNs used for image classification have been shown to be vulnerable to adversarial attacks that significantly reduce their accuracy. However, not much is known about the effectiveness of these attacks on DNNs employed for audio classification tasks. The goals of this research project are two fold. First, we apply popular adversarial attack methods from image domain including DeepFool and Fast Gradient Sign Method on DNNs for audio domain to understand their strengths and weaknesses. Second, we explore new adversarial attack approaches to address the unique challenges of audio data based on the understanding from the first goal. Our experimental results on real-world audio datasets show that attack methods from the image domain are not very effective for audio data. Biometric Data Segmentation for Classifying Stressed and Unstressed Signal Regions to Predict Alcohol Relapse

Presented by: Daniel Faronbi

Program: Multidisciplinary Undergraduate Research Training in Wearable Computing
Co-authors: Parastoo Alinia,Michael Cleveland, Ramesh Kumar Sah, Hassan Ghasemzadeh
Home Institution, Major, Class Standing: University of Nebraska Omaha/Lincoln, Computer
Engineering and Music Technology, and Senior

For years, segmentation has been an important concept in digital signal processing. Data can often be more easily analyzed when it is split into different parts. Different types of signals require different types of segmentation. It is hypothesized that signals from biometric sensors can be used to predict the likelihood of heightened stress, a risk factor for alcohol relapse. To verify this, 12 participants who wore Empatica's E4 wristband to collect data were studied. The participants wore the E4 wristband for over 12 days and it returned signals for electrodermal activity, heart rate, temperature, and other parameters. The purpose of this project is to find the best method of segmenting this biometric data to predict heightened stress levels more accurately in people with a history of alcohol abuse. Multiple approaches to determine the size of this segmentation window were considered. One approach considered density of skin conductance response calculated from separation of tonic and phasic activity of electrodermal activity. A second approach extracted features from several biometrics and considered the window size that produced the highest correlation between features. Finally, a combination of both approaches was employed by using skin conductance density as a feature corelated with features from other data. Early results show that the ideal window size is near 24-96 seconds.

Digital Assistant for Resilient Operation of the Power Grid Using NLI

Presented by: Jonah Davis

Program: Undergraduate Research in Smart Environments
Co-authors: Anshuman Lnu, Sanjeev Pannala, Anurag Srivastava
Home Institution, Major, Class Standing: University of Rochester, Computer Science, and Junior

Physical damage to the electric grids we rely on is impossible to prevent, especially during extreme circumstances such as natural disasters. However, with rapid and well informed decisions, grid operators can lessen the negative impact. The team at SGDRIL has developed a real-time tool to process and visualize the data collected by the smart components of the grid. Here, we present an addition to this tool that is able to access specific pieces of information quickly and simply through the use of a natural language interface. Built around NLPCraft, the tool uses model-based intent matching to parse a natural language user input, translate it into an SQL query, and return the result to the operator. While it is still in the early stages of development, the tool was able to answer over 90% of simple questions correctly in an average time of 568 milliseconds. These results suggest the viability of this approach as we continue development and add support for a broader range of queries.

Deep Reinforcement Learning for General Playing

Presented by: Luisiana Dominguez

Program: Undergraduate Research in Smart Environments
Co-authors: Larry Holder
Home Institution, Major, Class Standing: Lehman College, Computer Science, and Junior

Any type of artificial intelligent is designed to follow a pattern to learn and achieve a goal. When it comes to video games, agents are designed to play a specific genre, yet, when it comes to play a different type of genre, it will end up performing poorly. The goal of the research is to create an agent that can play different type of game to the same level of performance as the agent designed for the one of the individual games. We are pursuing this goal using virtual environments like VizDoom and OpenAI Gym and AI agents based on deep Q-learning networking. We compare the performance of a general agent to that of specific agents designed for different type of games. The general agent is likely to perform worse than the specific agents, but the question is by how much. The result of this research will help to develop better techniques to create general-purpose agents that perform well on multiple, diverse tasks.

Aiding the integration of automatically generated tests into pre-existing manually written test suites

Presented by: Bryn Loftness

Program: Undergraduate Research in Smart Environments
Co-authors: Venera Arnaoudova, Devjeet Roy
Home Institution, Major, Class Standing: Colorado Mesa University, Computer Science, and Senior

Automatic test generation tools have become increasingly prevalent and effective in improving fault detection, lowering costs, and reducing effort in producing necessary test cases for application test suites. While these automatic test generation tools are useful, they also produce redundancies in the test suite. These redundancies lead to reductions in performance and efficiency of the test suite, as well as increased difficulties relating to the maintenance of the application code base. To remediate these redundancies, related or overlapping test cases should be identified, clustered, and subsequently pruned from the suite. Currently the process of clustering and merging test cases is done largely by hand, which is often time-consuming and strenuous work. Previous research in this domain has allowed us to produce natural language summaries of test cases, termed test case scenarios. To continue toward the goal of making the manual merging process more efficient, we propose a methodology for automatically clustering analogous test cases. In our implementation, we analyzed similarity degrees produced in a variety of text analysis and information retrieval techniques. These techniques are within the scope of syntactic and semantic natural language processing of test case scenarios, as well as static analysis of test case code segments. These metrics are then used to identify key intersections and clusters of test cases. To evaluate effectiveness, a case study will be conducted with experts in the field to distinguish if the automatic clustering process is effective in easing responsibility and burden of manual merging of superfluous test cases.

Detecting Patterns and Anomalies in COVID-19 Spread using Dynamic Graphs

Presented by: Filipp Shelobolin

Program: Undergraduate Research in Smart Environments
Co-authors: Larry Holder
Home Institution, Major, Class Standing: Carnegie Mellon University, Statistics and Machine Learning, and Senior

COVID-19 has become a global epidemic that has affected the lives of all individuals in the world. Since the initial spread, numerous models have been created to predict and understand the spread of the Coronavirus. However, only a few of these consider global population movement as part of their model. We create a dynamic graph representation of the spread of the Coronavirus consisting of countries (nodes) connected by population movement (edges). Combining multiple datasets, we add node attributes including COVID-19 cases, local mobility, geographical and meteorological features, and policy decisions. We propose a model that explains the proportion of susceptible populations infected daily as a function of both the proportion of infected populations and the expected number of incoming infected populations. We also create a visualization tool that allows for running a simulation in which airports are closed, and comparing the results. We find that the expected number of incoming infected populations is related to the infection rate, and conclude that closing airports earlier can have compounding effects on slowing down Coronavirus growth. Although our model shows a relationship between population movement and infection rate, it does not perform well on train or validation sets nor in predicting future spread. The next step is to adapt pattern discovery and anomaly detection algorithms to detect new patterns in the graph that may help us understand COVID-19 spread and possible techniques for disruption.

Minimizing Wireless Transmissions of Wearable Bioelectronics Using Deep Echo State Networks

Presented by: Kaylee Trevino

Program: Undergraduate Research in Smart Environments
Co-authors: Subhanshu Gupta
Home Institution, Major, Class Standing: The University of Texas at Austin, Electrical and Computer Engineering, and Senior

Wireless transmissions consume the majority of energy from bioelectronic wearable devices' low-power sensor nodes. Thus, there is a need for reducing the power used by these transmissions as well as maintaining high-precision and accurate decision-making. This work uses the MIT-BIH database and corrupts the data by randomly adding six different abnormalities which are consistent with unhealthy electrocardiogram (ECG) waveforms. The work then proposes the use of a Deep Echo State Network (Deep ESN) to predict when wireless transmissions should be made. Unlike prior methods, this model is capable of identifying different abnormalities when introduced to various artifacts. This Deep ESN performs with an average of about 1.16% MSE and 0.0007 standard deviation when predicting if one of the abnormalities is present and about 8.80% MSE and 0.0081 standard deviation when predicting which of the six abnormalities is present.