**2024 SURF Proposal Projects**

Project: **Community Resilience Planning Sentiments Following a Natural Hazard Event**

Division: Applied Economics Office

Advisor: Gore, Christina

Description: This project will evaluate changes in discussions surrounding increasing resilience to future natural hazard events immediately following a community experiencing a natural hazard event. The analysis will include data from Google Trends as well as X (formerly known as Twitter) data. Google trends data will be used to show the keywords that are commonly searched for following a natural hazard event. Those keywords will also help inform the data set of tweets used for analysis. The tweets will then be coded based on the types of sentiments that are expressed by the tweets and that data will be analyzed.

Project: **Advancing the Nation’s Risk Communication Strategies during Risk, Crisis, and Disaster**

Division: Materials And Structural Systems

Advisor: Herovic, Emina Dr.

Description: Social science understandings of risk, crisis, and disaster can provide important and valuable insights into means by which to prevent injuries and save lives. This work will involve examination of communication strategies and modes during disaster and the comparative benefits, drawbacks, implications, and future directions in order to help strengthen and advance best practices and standards for protective action messaging.

Project: **Investigation of Sulfide Mortar Bar Expansion**

Division: Materials And Structural Systems

Advisor: Dixon, Patrick G. Dr.

Description: Concrete foundations of buildings in Connecticut have undergone extensive deterioration, which has been attributed to aggregate containing pyrrhotite, a set of iron sulfide minerals, deficient in sulfur and reactive compared to pyrite. Pyrrhotite’s reactivity, variable structure, and similarity with pyrite present challenges in the quantification of its tolerable content in concrete aggregate. Thus, investigations often use mortar bar expansion tests to assess pyrrhotite reactivity. Mortar bar tests subject a specimen composed of cement and the aggregate of interest to exposure conditions. Specimen expansion is measured over time. This project focuses on the expansion measurement of mortar bars with pyrrhotite-bearing aggregate.

Project: **Study of Degradation Mechanism and Failure Mode of Polymers used in Photovoltaics**

Division: Materials And Structural Systems

Advisor: Gu, Xiaohong

Description: Understanding the degradation modes of polymeric components used in solar cells during services is critical to the development and assurance of photovoltaic technology. In this study, the degradation of polymeric backsheets aged in the accelerated laboratory conditions will be analyzed using spectroscopic, microscopic and mechanical techniques such as attenuated total reflection Fourier-transform infrared spectroscopy (ATR-FTIR), laser scanning confocal microscopy and tensile tester. The mechanisms of chemical, microstructural and mechanical degradation will be studied. The results will be used to understand the root causes of the backsheet failure and provide scientific basis for material selection and product development.

Project: **Mitigation Efforts for Pyrrhotite in Concrete**

Division: Materials And Structural Systems

Advisor: Watson, Stephanie

Description: In parts of Connecticut and Massachusetts, aggregate containing pyrrhotite was unknowingly used in concrete mixtures used to build thousands of structures over several decades. As these structures age, the pyrrhotite has begun to oxidize resulting in damage ranging from stains and popouts to severe cracking and loss of structural integrity. Several aggregate screening frameworks have been proposed; however, little research is available regarding mitigation techniques for already placed structures. This study aims to evaluate several types of sealants and their ability to mitigation water absorption and oxygen permeability after initial application and after accelerated aging laboratory protocols.

Project: **Development of non-destructive polymer degradation measurements for photovoltaic cells**

Division: Materials And Structural Systems

Advisor: Aiello, Ashlee R. Dr.

Description: Prevention and understanding of early failure mechanisms in photovoltaic modules is needed to economize solar energy. The polymeric components in photovoltaic modules degrade during outdoor exposure, which can result in multiple failure mechanisms including cracking, delamination, and discoloration. While many characterization methods are well suited for polymer degradation studies, they require disassembly of the module and are limited to post-mortem analysis. This project will focus on the development of new non-destructive measurements to study polymer degradation in either fully assembled modules or under in-situ conditions (e.g. during exposure to temperature, humidity, or mechanical strain).

Project: **Analysis of Fiber Reinforced Polymer (FRP) Retrofitted Shear Walls with Openings**

Division: Materials And Structural Systems

Advisor: Dukes, Jazalyn D.

Description: Fiber reinforced polymer (FRP) composites have been used and researched extensively for retrofit of concrete components such as columns and beams. However, less research has been devoted to reinforced concrete (RC) shear walls retrofitted with FRP. In order to understand the landscape of research on the topic, a database of experimentally-tested FRP-retrofitted shear walls has been developed. For this project, the student will begin investigating a particular type of wall found in the database: walls with openings. This project will demonstrate the benefits of FRP retrofit for RC walls with openings, as well as prepare the groundwork for developing modeling parameters for these walls in the future.

Project: **Verification and validation of computational models for analyzing future impacts of sea level rise, hurricanes, and adaptation in Galveston, Texas.**

Division: Materials And Structural Systems

Advisor: Sanderson, Dylan R. Mr.

Description: This project will contribute to the verification and validation (V&V) of new computational models for community resilience planning. Community resilience planning aims to reduce both the immediate impacts of a disaster and the time it takes to recover. The project will utilize Galveston, Texas as a testbed community as it is subject to both sea level rise and hurricanes. Under the guidance of the project advisor, the SURF student will first learn how to run the computational model for evaluating future community resilience. Once familiar with the model, the student will identify and perform model tests to assist with V&V. This SURF project will contribute to a larger research project aimed at developing new models for community resilience planning under future climate conditions.

Project: **Study of Fluorescence Microscopy and Related Petrographic Methods Applied to Concrete Materials**

Division: Materials And Structural Systems

Advisor: Strack, Cody M. Mr.

Description: Examination of hardened concrete using petrographic methods is necessary to adequately understand the material and potential degradation methods. Many techniques are available to the concrete petrographer, including the use of light and fluorescence to better illuminate specific features, such as the air void system. Specific equipment and software tailored to petrographic examination can enhance conclusions, benefit the presentation of data, or decrease required analysis time. This project will examine multiple methods in the determination of phase fractions present in concrete samples to determine their capabilities.

Project: **Degradation study of post-consumer PET water bottle using the NIST SPHERE**

Division: Materials And Structural Systems

Advisor: Sung, Lipiin

Description: PET (polyethylene terephthalate) has been widely used as in food packaging, beverage containers and textile industries. Plastic wastes are a potential risk for the ecosystem and pose some public health concerns following degraded plastics particles release into environments. Understanding how weathering affects PET and its interaction with environment is important to mitigate this issue. The selected materials are post-consumer PET water bottles. This project will focus on generating weathered plastic particles with the NIST SPHERE, where macro-samples or films of plastics are UV-weathered while immersed in water (or simulated ocean water) or under high humidity, dry conditions. Fourier transform infrared spectroscopy (FTIR) and laser scanning confocal microscopy will be used to characterize chemical properties of UV-degraded surface and the size and distribution nano-/micro- plastics particles as a function of UV exposure time. The outcome of this project would provide spectral database (FTIR) of weathered plastics, particles sizes of the microparticles at various temp and generation of more relevant, weathered microplastic particles. The outcome of this project would provide spectral database (FTIR) of weathered plastics, generation of more relevant, weathered plastics and microplastic particles. These weathered plastic particles will be used to evaluate key toxicological assays, and develop microplastic and nanoplastic characterization methods (e.g., microscopy, pyrolysis GC-MS) in collaboration with other NIST scientists in this program.

Project: **Measurement of Pressure Loss in Modern Plumbing Fittings**

Division: Building Energy and Environment

Advisor: Milesi-Ferretti, Natascha

Description: Premise plumbing design is still based on methods developed in the early 20th century. Therefore, there is a need to develop right-sizing approaches that reflect the use of modern materials and fittings and current needs to increase water efficiency and quality. A brand-new facility has been designed and constructed at NIST to support the development of a test method for measurement of pressure loss in pipes and fittings in sizes commonly used in residential buildings. The student will acquire hands-on experience on performing pressure loss measurements and calculations, using LabView, analyzing and documenting data, and presenting findings.

Project: **Measuring Water Quality and Efficiency in Building Plumbing Systems**

Division: Building Energy and Environment

Advisor: Ullah, Tania

Description: This project aims to explore ways to improve the performance of plumbing systems in modern buildings in terms of water quality, water conservation, and energy efficiency. NIST has designed and operated a laboratory test rig that allows us to quantify chemical and physical water quality parameters and concentrations of pathogenic organisms in water heaters. The student will gain hands-on experience making these measurements and learning microbial analysis techniques, such as culturing and droplet digital PCR (ddPCR).

Project: **Measuring Soot Deposition on Surfaces Using Grayscale Image Analysis**

Division: Fire Research

Advisor: Mensch, Amy

Description: This project is the final component of a project exploring non-invasive ways to measure how much soot has deposited on surfaces after a fire has occurred. This is important to enable fire investigators to obtain reliable measurements of soot deposition for forensic fire reconstruction. Direct methods to measure soot involve placing pre-weighed targets on the surface and then measuring the change in mass after the fire. We will test a grayscale image analysis method, where photos of soot-laden surfaces will be processed to compare the grayscale value to the amount of soot deposition determined from pre-weighed target measurements. The performance of the grayscale image method will be compared to a non-invasive photoacoustic method that the investigators have previously tested.

Project: **Material Flammability apparatus development and testing**

Division: Fire Research

Advisor: Leventon, Isaac

Description: The Engineered Fire Safe Products (EFSP) Project in the Fire Research Division at NST is focused on the development and application of the capabilities (experimental & computational analysis tools) to enable quantitative prediction of material flammability behavior (e.g., ignition, steady burning, fire growth).

This SURF project will focus on the construction and calibration of a miniaturized gasification apparatus (one of the bench scale apparatus needed to maintain these capabilities).

Project: **Experimental Characterization of Flame Heat Transfer Mechanisms**

Division: Fire Research

Advisor: Leventon, Isaac

Description: The Engineered Fire Safe Products (EFSP) Project in the Fire Research Division at NST is focused on the development and application of the capabilities (experimental & computational analysis tools) to enable quantitative prediction of material flammability behavior (e.g., ignition, steady burning, fire growth).

This SURF project will focus on preparing samples and running tests in some of the bench- and intermediate-scale apparatus needed to maintain these capabilities, with a special emphasis on g-scale calorimetry experiments and intermediate-scale wall flame experiments.

Project: **Digital twin development for a coordinate measuring machine**

Division: Intelligent Systems

Advisor: Shao, Guodong

Description: A manufacturing workcell to support digital twin research has been established at NIST. The workcell comprises robots, a CNC machine tool, and a coordinate measuring machine (CMM). A digital twin of the workcell is being built using data collection and communication protocols, modeling tools, and interface standards currently used in industry. The data pipeline is supported by MTConnect standard, which enables modeling of the physical equipment and the streamed data as the digital twin input. Digital twins of individual equipment are being developed and will be integrated. The digital twin of the robots and machine tool have been built using different tools. Efforts are now underway for the CMM digital twin. CMMs are machines that perform product quality conformance regarding their designs through geometric measurements of the parts. The SURF student will work with the NIST team to build and validate the CMM digital twin and implement a method for inputting streamed data into the model of the CMM to update the developed models with the real-time status of the CMM. The skills that the student needs are geometrical design (CAD) and computer programming (e.g., python).

Project: **Robotics Research and Industry Equivalence**

Division: Systems Integration

Advisor: Harrison, William S.

Description: Robotics play a clear and inevitable role in our technical future; however, novel research and techniques often fail to make it onto the manufacturing floor. This is because a gap exists between robotics research and industrial robotic implementation.

This research seeks to explore the differences between industrial robot work cells and the typical robot research environment. If time permits, the student will lead the effort in making the research work cell more closely approximate an industrial setting.

Project: **Evaluating 3D sensor performance using planar and non-planar targets**

Division: Systems Integration

Advisor: Rachakonda, Prem

Description: The Sensing and Perception Systems Group of the Intelligent Systems Division is working on multiple activities related to the development of standards for 3D sensors used in vision-guided robotics and manufacturing automation. Some of the sensors have higher noise in one of the three dimensions. This project will involve exploring the performance of multiple sensors in measuring planar and non-planar targets (such as spheres). Various sensor parameters will also be explored to identify optimal parameter space. Initial testing and analysis will be manual, and if time permits, the process will be automated using a robotic arm.

Project: **Investigating Effects of Terrain Porosity on Map Generation and Navigation by Advanced Robotic Systems**

Division: Systems Integration

Advisor: Fraley, Alex M

Description: The Sensing and Perception Systems Group of the Intelligent Systems Division is engaged in the development of standards for measuring the mobility and mapping capabilities of robots, particularly for emergency response. This project explores the impact of surface variability, such as porosities of grated versus non-grated surfaces, on autonomous robots' map generation and terrain traversal abilities. It aims to address and document challenges and current technological gaps, like the effects of different surface types on map accuracy, to aid standards development and enhance autonomous robotics' utility in critical real-world applications, including disaster response and nuclear cleanup efforts.

Project: **Developing algorithms to recognize hand gestures while wearing an Exoskeleton hand**

Division: Systems Integration

Advisor: Virts, Ann M.

Description: The Sensing and Perception Systems Group of the Intelligent Systems Division is engaged in the development of standards for exoskeletons. We are developing low-cost marker less body tracking systems to validate the fit to the user. This project would entail the development of algorithms to recognize multiple hand gestures, as well as tracking the hand while preforming an assembly task using the NIST assembly boards. In addition, to hand tracking algorithm, to develop image processing techniques to be able to locate joints on the exoskeleton hand post processing.

Project: **Emergency Response Robots and Drones**

Division: Systems Integration

Advisor: Jacoff, Adam

Description: The Emergency Response Robots project is leading an international effort to develop standard test methods for robots and drones that can perform extremely hazardous tasks from safe standoff distances. These standard tests are used to evaluate various system capabilities and remote operator/pilot proficiency. You can develop small 3D printed robots that can become the first truly disposable robots used to help find victims in collapsed structures. Or you can evaluate small drones used to quickly explore indoor and outdoor environments to inspect objects. Either endeavor will prepare you as a resource for robot and drone projects at your school.