EL Proposed 2020 SURF Projects by Division

Greetings SURF 2020 Applicants. The following list of projects are "proposed" and are provided to assist you with the development of your statement of interest, and in helping you request a letter of reference. Projects are listed by Division as follows:

- Engineering Laboratory Office Division (730)
- Materials and Structural Systems Division (731)
- Energy and Environment Division (732)
- Fire Research Division (733)
- Systems Integration Division (734)
- Intelligent Systems Division (735)

NO GUARANTEE DISCLAIMER

THERE IS NO GUARANTEE THAT ALL OF THESE PROJECTS WILL BE AVAILABLE, OR WILL BE EXACTLY AS DESCRIBED. PROJECTS ARE SUBJECT TO FUNDING AND STAFFING VARIABILITY. THESE DESCRIPTIONS, HOWEVER, ARE INTENTED PROVIDE YOU WITH INFORMATION TO HELP YOU HONE YOUR APPLICATION.

New Projects Just Added:

Systems Integration Division - 734

Using Category Theory to Accelerate Data integration in Additive Manufacturing Processes

Large amount of data are used and generated from additive manufacturing systems. The data defined and generated by different AM systems are not defined in the same way. Hence, it is very difficult to discover and compare AM builds with similar process settings but built using different AM systems. In this project, we plan to use a new mathematical foundation for AM data integration called Category Theory (CT). CT is the branch of mathematics concerned with modeling and transforming pure structure. CT also has representations for different structures and mappings that can preserve that structure. More specifically, this project is to demonstrate the use of CT constructions to map the process settings from two different AM systems using a tool named Categorical Query Language (CQL) (https://www.categoricaldata.net/). A demonstration will be created to discover builds with similar hatch distance in an AM material database.

Data Registration System Design and Development

The number and types of sensors used for monitoring laser-powder bed fusion processes for metal additive manufacturing are increasing. Each sensor has a unique coordinate system for reporting the collected data. Sensor data fusion becomes issue for monitoring the powder fusion processes and predicting the material properties in the part. The summer research work involves developing some basic statements on describing a software tool for data registration. Functions of the tool include organizing data based on data schemas, establish relationships among related data, and publish the data to a database. Some programming skills are required to develop a prototype.

Optimization of Standardized Methods for Concept Trending with Natural Language Processing Technologies

To best guide our path into the future, we must first clearly see where we've been. Areas of scientific research will evolve and change over time lead both by directions of policy and new developments in technology. Understanding those trends over time can help predict future areas of focus, help to highlight potential research needs, and identify fertile areas of collaboration across communities that may not traditionally interact and use different expressive language based on their respective domains. There has been recent efforts, particularly in the medical domain, to use Artificial Intelligence and Machine Learning to characterize and synthesize large collections of research publications with implications for guidance, concept searching, and knowledge discovery. The goal of this project is to test, upgrade, and optimize a previously created computer pipeline designed to extract and trend concepts, or areas of interest, from libraries of scientific publications over time. The student will need to have a basic understanding of python and implementing python related packages. Although not a requirement, basic familiarity with any of the following would be also great benefit to potential applicants: Natural Language Processing (NLP), time series modeling, clustering, visualization, or advanced coding methods. NLP technologies are rapidly expanding through many aspects of modern academics, industry, and leisure. Students will gain or increase their familiarity with NLP concepts and derive a solid understanding of developmental testing for research tool development and optimization. The proof of concept data sets will focus on manufacturing related texts, but the skills and any developed tools will have broader applications that could be useful in any domain.

Intelligent Systems Division - 735

Automated Door Opening using AI, 3D Sensors, and Mobile Robots

Emergency Response Robots are used in situations that are dangerous for humans. Opening the door of a suspicious vehicle is a challenging tele-operation task for humans. Robots could learn to open vehicle doors autonomously. The NIST "AI for Door Opening using Robot Manipulators" project is exploring machine learning (ML) techniques in order to teach a mobile robot to open

vehicle doors using various sensing technologies. NIST is interested in researching different techniques including teaching by demonstration using actual doors and instrumented humans, unsupervised learning, learning through demonstration in VR and AR, learning through simulation using real world data, etc.

Software Integration of a Web-based Robot Interface

The Sawyer robot is a collaborative arm by Rethink Robotics which comes with a browser-based graphical user interface, Intera Studio. This interface can be accessed on the robot's screen or on an external computer but does not allow for text-based programming while in factory mode. We would like to integrate the Sawyer with the Collaborative Robotics Programming Interface (CRPI) developed by NIST. The goal of the project is to emulate the commands sent to the robot from Intera Studio and create a software interface that can communicate with and control the robot.

Probabilistic damage tolerance analysis for additive manufacturing

Additive manufacturing (AM) enables creation of complex features with reduced weight. Biomedical and aerospace industries are interested in adopting AM for critical components. The lack of information on defect detection capability and fracture probability, however, is inhibiting wider adoption. Probability of detection (POD) curve estimates defect detection capability of a non-destructive evaluation system. Probabilistic damage tolerance analysis incorporates variables such as anomaly distribution, POD curves, residual stress, and crack growth rate to predict probability of fracture. A case study will be performed by designing an AM part, determining a POD curve, and estimating probability of fracture.

Fiducial Design for Surface Analysis of AM Fatigue Specimens

The goal is to develop and test fiducial markers on additively manufactured (AM) fatigue specimens for use in pre/post fracture surface characterization. Currently, there is little known about the effect of the as-built AM surface and intelligent design of fiducial markers will be required to accurately relate pre and post fatigue test surfaces. The student will work with the group's machinists and the machine shop to design various fiducial markers on the fatigue specimens, investigate the uncertainty of measurements using an optical focus variation microscope (FVM) and x-ray computed tomography, as well as the limitations of the various measurement systems.

Destructive Surface Analysis of AM Parts

The goal of this work will be to investigate the use of destructive surface analysis to determine uncertainty of optical (non-destructive) surface measurements on parts fabricated by additive manufacturing (AM). Currently, understanding of the uncertainty of optical surface topography measurements on surfaces such as those built by AM is limited. One method hypothesized to improve that understanding is to use destructive methods to section the part for measurement with a standard optical image microscope. The student will work with NIST staff to optimize and carry out a measurement routine, as well as perform the post measurement data preparation and analysis.

Exoskeleton Survey Analysis

Exoskeletons are becoming useful in industrial, medical, response, military and even recreational applications. The NIST research team has tested subjects performing potentially standard tasks. Surveys have been completed by over 30 people who have performed tests while not wearing and while wearing exoskeletons. Upon test completion, the subject filled out a survey about the exoskeleton and the test method. This data requires analysis to uncover aggregate results across all subjects to find correlations to gender, height, fatigue, and other metrics that can help improve exoskeletons, exoskeleton test methods, and to lower risk to humans wearing exoskeletons to complete tasks.

Wearable sensors for human-robot interaction

Human-robot collaboration in manufacturing settings are largely driving by the safety concerns associated with the close proximity and potential contact with industrial robots, tooling, and process-based hazards. A leading contributor to these safety concerns is the uncertainty associated with human position, actions, and intent. Advanced sensor suites are required to monitor the human while in the collaborative work zone but are prone to interference and measurement error given the unstructured nature of human-robot interaction. This project focuses on the development of wireless, wearable sensors that can be used to facilitate natural movements while in the collaborative work zone without compromising sensing performance, process efficiency, or safety.

Evaluation of Exoskeleton fit

Exoskeletons are becoming common place in industry. Factories, like Toyota are make exoskeletons required PPE in some applications on the assembly line. NIST researchers are developing Standard Test methods and measurement science towards comparison of results in which to evaluate the capabilities of the systems.

Designing a Sensor Board and Interface for Stretchable Electronics

Exfoliated intercalated graphite composite sensors are highly deformable making them ideal for flexible sensors, soft robots, and wearable applications. Currently, the sensor boards reading the sensor response are bulky, making close packing of the sensors difficult. The sensor boards can be redesigned to reduce their footprint. This project focuses on the redesign of this sensor package to achieve markedly reduced footprints without compromising sensing performance. Specific process-oriented goals also include 1) to apply the required pressure needed to maintain good contact with the capacitor, 2) to reduce the time and effort required to facilitate sensor assembly, and 3) to improve the sensor yield and lifetime.

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Engineering Laboratory Office (Division 730)

Web Application Development for an Economics Research Project within the Engineering Lab

The Engineering Laboratory has an exciting web application development Surf project this summer. The project entails creating a web application where you will learn or hone your existing web development skills while learning about administering a web environment. Work with a technology professional to develop a web application for an Engineering Lab/Economics research project using current open source technologies such as python, javascript, html, json, flask, docker and postgresql. You will develop code and documentation based on specific project requirements.

Natural and Built Infrastructure Costs and Benefits for Community Resilience

Disasters of all varieties can cause devastating damage to community infrastructure. Measures are often taken to reduce the negative impacts of such disasters. However, there is strong uncertainty around when disasters may occur for certain hazard types. Infrastructure within a community is a system of systems; if there is failure in one part, it is likely that the entire system will be disrupted. For this reason, community resilience planning should take place ahead of time; vulnerable structures should be properly reinforced against potential hazard events.

This SURF project will develop a database of natural infrastructure and built infrastructure costs and benefits to produce case examples for the Applied Economics Office's Economic Decision Guide Software (EDGe$) Tool. A meaningful report on the benefits and costs of implementing several potential plans to improve resilience in comparison to the base case (i.e., taking no planning action).

Development and Testing of RESTful Web Services for IoT Smart Sensors

IoT devices are everywhere. Among them are smart or 'intelligent' sensors. They are important components of Internet of Things/Cyber-Physical System (IoT/CPS).The ability to access and use the data from smart sensor is what will define the impact of the Internet on the physical world. Access and data usage is made possible through reliable communications and one of the challenges is interoperability (the ability of one component to receive and use the information sent from another). Representational

State Transfer (REST) RESTful Web service is one of most popular IoT communication protocols. IEEE 1451 standards define a set of standardized interfaces for smart sensors in order to achieve sensor data interoperability.

This project will define RESTful Web services for smart sensors using Web application description language (WADL), design and develop the RESTful WS using Java or Python for smart sensors, and develop smart sensor tester (RESTful WS client) using SoapUI tool, and conduct interoperability testing between them, and provide a technical report.

Materials and Structural Systems Division (731)

Chemical and Mechanical Characterization of Degradation of Polymeric Components used in Solar Cells

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 and in the fielded modules under different climates will be analyzed using spectroscopic and mechanical techniques such as attenuated total reflection Fourier-transform infrared spectroscopy (AT-FTIR) and tensile tester. The mechanisms of chemical 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 section and product development.

Tasks or milestones:

1. Review the references and prepare the samples of PV backsheets.
2. Expose samples to the laboratory exposure conditions at different environmental conditions.
3. Characterize the chemical and mechanical degradation of the laboratory exposed samples and outdoor exposed samples using spectroscopy and microscopy.
4. Analyze the data, present the results and write a report.

Investigating aging, degradation, and performance of polymeric exteriors after weathering

Vinyl siding is one of the most popular home siding materials in the United States due to its ease of installation, aesthetic versatility, low cost, and option for insulation backing. However, relatively little is known regarding its long-term appearance, mechanical durability, and insulation performance following years of continuous weathering. To address this, weathering studies will be performed in the NIST SPHERE and with a QUV Weatherometer to accelerate the UV-driven degradation of siding materials. In addition to commercial siding materials, research formulations will also be studied to determine the influence of various additives on siding aging and performance. Following exposure, samples will be characterized with a variety of spectroscopic, electron microscopy imaging, and mechanical performance testing techniques. Data collected will identify changes in polymeric siding samples from the molecular through macroscopic level and inform the extent to which various accelerated weathering

conditions deteriorated the material. These findings will be used to develop a fundamental understanding of weather-driven decreases in siding longevity.

Cross-sectional depth profiling of degraded multilayer photovoltaic backsheets after accelerated laboratory UV exposure

Understanding the resilience of multilayer polymeric backsheet materials is critical to knowing the overall performance of a photovoltaic (PV) module. Multilayer polymeric backsheet materials are key components of PV modules in which it provides protection against environmental conditions such as ultraviolet (UV), moisture and extreme temperatures. Due to the nature of multilayered films, this study analyzes film cross-sections obtained by cryo-microtomy of samples with flat surfaces parallel to the thickness direction (i.e., depth profiling) to investigate the chemical and optical property changes that occur during degradation. Commercial polymeric backsheet films will be weathered using accelerated laboratory exposure on the NIST (National Institute of Standards and Technology) 2-meter diameter integrating SPHERE (*Simulated Photodegradation via High Energy Radiant Exposure*). The UV irradiance at approximately 170 W/m² between 300 nm and 400 nm with various elevated relative humidity and high temperature conditions will be used to study the effects of UV, moisture and heat on the backsheet materials. This project will focus on the multilayer structures using laser scanning confocal, while the chemical and optical depth profiling of aged and unaged samples will be examined by Raman spectroscopic imaging, micro-UV and micro-IR. This depth profiling study will continue to bring new understanding to the mechanisms of failure observed during weathering.

Visualizing Community Resilience

The goal of this project will be to explore various methods and techniques for visualizing and delivering community resilience data to both researchers and the general public. The successful candidate will perform this work utilizing a database of indicators and their associated variables, and a county-level dataset which explores key issues in the measurement of physical, social and economic aspects of community resilience. The visualization methods and techniques could include, but is not limited to, Tableau software; web-based GIS data delivery mechanisms; and any other database visualization methods known to the student.

Study of Service Life of Materials used in Building Infrastructure Products

Polymers are used in products for many industries/applications. Research in the Infrastructure Materials Group has focused on building infrastructure products (pipes, cables, composites in building structures) to determine resilience of entire systems. Product performance is essential for ensuring consistent operation and predicting continued operation with age and/or after major catastrophes (tornados or hurricanes). This research project will focus on the determination of service life for existing and new products (electrical cables) and standardization of methodologies and parameters for a set of condition monitoring tests (CMTs). Several CMTs will be used in evaluating commercial products, each exposed to well-controlled exposure conditions. Samples, characterized to establish baseline values, will be subjected to exposure environments, measured after each exposure, and assessed for temporal changes in performance.

Improving the Uncertainty in Characterization of Trace Evidence Automotive Paint

Trace evidence is the broadest, least defined area of forensic science. Analysis of trace evidence seeks to connect people, places, things, times, and activities to identify criminals and understand crimes. While trace evidence has been used since the beginning of forensic science, it has become controversial due to over interpretation of evidence and the human-based observational methods that lack accuracy and precision. This project will test and measure capabilities/uncertainties of current trace evidence methods, particularly for automotive paints. Research will focus on examination of automotive paints using Fourier Transform infrared (FTIR) and Raman spectroscopies as a function of weathering. Data collected will be used to develop an automotive paint database and a standard reference material for weathered paints.

School Recovery Following Disasters

This project is focused on improving our understanding of the recovery of schools and other social institutions important to communities after disasters. Using interviews with school officials conducted at multiple post-disaster time points, the student would use qualitative analysis methods to identify the major themes in the interviews. The student would document the results of the analysis through a presentation, as well as the development of a narrative with example quotes from the interviews and supporting background literature. The skills required for this project include knowledge of qualitative social science methods. Ideally, the student would have basic Human Subjects Research training. The work will support ongoing research on the recovery of schools and hospitals following disasters, such as hurricanes, floods, and fires.

Fiber Reinforced Polymer (FRP) Retrofitted Reinforced Concrete Shear Wall Database

Fiber reinforced composites have been used and researched extensively for retrofit of concrete components such as columns and beams. Research examples of this retrofit technique for shear walls is not as well documented, particularly in the US. A database of FRP retrofitted reinforced concrete shear walls is in development at NIST. This database seeks to include all available specimens that have been experimentally tested under lateral loads. For this project, the student will continue developing this database by inputting details of past experiments on shear walls with retrofitted fiber reinforced composites and creating a more user-friendly platform. The student may also conduct statistical analyses on the variables in the database to determine the characteristics of the walls in the database and to identify any gaps in the research. For this project, a knowledge of and interest in civil and structural engineering is desired. A knowledge of statistical analysis and programming or coding language such as Matlab or SQL is a plus. Outcomes of this project will inform the design of a large-scale experimental program at NIST and will inform codes and guidelines development for the retrofit of shear walls.

Technical Implementation of the Strategic Plan for the National Windstorm Impact Reduction Program (NWIRP)

The National Windstorm Impact Reduction Program (NWIRP) strategic plan outlines three goals; Understand windstorm processes and hazards, Improve the understanding of windstorm impacts on communities, and Improve the resilience of communities nationwide. The first goal, "Understand windstorm processes and hazards" forms the foundation of NWIRP and provides research opportunities to advance the science of windstorm hazard characterization. While most engineering-based post windstorm investigations focus primarily on wind, recent experience demonstrates that extreme rainfall

is comparable to wind as the progenitor of weather disasters, especially with respect to disaster mortality. Unfortunately, in some instances ground-based observing systems are insufficient for measuring extreme rainfall. This project will focus on a meteorological analysis of extreme rainfall in landfalling hurricanes using multiple in situ and space-based rainfall measurement systems to improve understanding of the range of extreme rainfall estimates.

Desired Qualifications: Proficiency with Microsoft office software, especially excel for basic statistical analyses. Desire to work on projects of an interdisciplinary nature. Basic familiarity with other statistical tools (e.g., Python, Matlab, etc.) a plus but not required.

Rheology of Dense Suspensions with Application to 3D Printing

We are carrying out research on the rheology of dense suspensions with application to 3D printing of cement-based materials. This includes opportunities for making rheological measurements as well as computational modelling of flow in complex geometries. An important component of research would be post analysis of simulation data as well as visualization of suspension flow in a variety of different scenarios including flow in a pipe or rheometer.

Service Life Prediction of Polymeric Materials

The NIST SPHERE is an accelerated weathering system, which is one part of a Service Life Prediction Program to test durability of polymeric materials. The current effort is to transfer this technology to industry with a new smaller sphere device, but first it must be tested and benchmarked to the current 2-m SPHERE. Research will focus on chemical examination of an epoxy amine system using molecular spectroscopies as a function of exposure. Data collected will be used to test reciprocity, a property of light intensity, duration, and reactions to light-sensitive materials, and incorporated into a final service life model.

Develop an Interactive Screening Tool for Community-scale Resilience Planning - Harrison

Hurricanes in 2017 caused a combined $265 billion in damage and resulted in widespread displacement of survivors (FEMA After-Action 2017 Report). The Community Resilience program at NIST provides guidance on planning to reduce the severity of impacts from hazards. At NIST, an interactive screening tool for community-scale resilience planning is under development to facilitate stakeholder exploration of solutions that perform well with respect to costs, recovery, and other objectives. This research experience will involve supporting the Community Resilience Program through help in various phases of research, including in literature search (e.g., organizing a Zotero citation database), extending and testing of models, and writing up results.

Characterization of Rheological Properties of 3-D Printed Cementitious Paste

Additive manufacturing (AM) or 3-D printing is an emerging topic in the construction community. While this technology has existed for several decades and used extensively in other industries, it's adoption by the concrete construction community is novel and requires a new set of performance criteria for cementitious materials. Rheology is critically important to the success of a 3-D printing and must be controlled for each stage of the printing operation. The quality of the printed structure and the ease with which it is created are lined to properties such as yield stress, plastic viscosity, and their time-dependent behavior. The objective of this project is to characterize the rheological properties of

cementitious paste used in 3-D printing applications and correlate them to a set of standard printing patterns.

Precast Concrete Moment Frame Connections with Enhanced Robustness

A robust structural system is one that can withstand localized damage, such as the failure of a column, without widespread (or disproportionate) collapse. The Structures Group at NIST carries out both experimental and numerical research aimed at investigating and improving the robustness of structural systems commonly used in building construction in the United States. Previous testing, conducted by NIST, has identified potential vulnerabilities in welded link plate connections for precast concrete moment frames under column removal scenarios, and five new alternative connection details have been developed to enhance the robustness of these systems. The next experimental phase is the investigation of the flexural performance of these five alternative connection concepts at five-eighths scale. Successful completion of these tests will lead to a better understanding of the performance of the alternative connection concepts and will lay the groundwork for future full-scale connection testing.

Accelerated conditioning of fiber-reinforced polymer composite retrofits used in buildings and infrastructure

Strategies to assess the long-term performance and lifetime of fiber reinforced polymer (FRP) composites retrofitted to bridges and structures are important to improve design specifications, long-term inspection protocols, and implementation of proper maintenance procedures. Although durability data is prevalent for different FRP materials alone, less durability data is available on how the performance of FRP composite/concrete assemblies changes in various environments. In this study, the durability of FRP composite/concrete assemblies will be systematically investigated using accelerated weathering. A series of FRP composite/concrete assemblies were fabricated and exposed to accelerated weathering conditions that have been found to be most detrimental to FRP composites and their bond to concrete. In this study, sample assemblies (FRP attached to concrete) will be weathered under one or more relevant conditions, after which, chemical, thermal, and mechanical methods will be used to characterize sample degradation.

Student interns will have the opportunity to:

1) Learn and use a range of analytical techniques, record and process experimental data, and assist in preparing technical reports.
2) Assist in designing, setting up, and removing samples from weathering chambers.
3) Measure degradation of FR composites with infrared spectroscopy, thermal techniques, and Raman microscopy.
4) Measure mechanical property changes using tensile and/or three-point bending tests.

Experience with composites, (surface) analytical chemistry, polymer chemistry and/or any chemistry or materials science engineering experience is a plus.

Polymer Modified Cement for Additive Manufacturing

Additive manufacturing (AM) or 3-D printing in the construction community has the potential to revolutionize the way in which structures are built. The speed at which structures are built and the need

for reinforcements are two challenges that must be overcome before AM can be adopted by the construction industry. One method to address these challenges is to mix a fast-setting polymeric material into the cementitious material. The fast-setting properties of the polymer will increase the early-age strength of the cement, allowing more material to be layered at a faster rate. Additionally, the inclusion of polymer may increase the ductility of the hardened cement/polymer composite, thereby reducing the need for reinforcement. The objective of this project is to characterize the setting characteristics and late-age mechanical properties of cementitious materials with several types of fast-setting polymers that have been preliminarily identified as providing improved early -age and late-age properties of cement. Furthermore, the effect of dispersing agents on the cement setting process will be investigated to help elucidate the mechanism(s) of polymer interactions with cement particles.

Windstorm Impact Assessment

Hurricanes and tornadoes are among the most destructive natural hazards facing the United States. This project will work to help document the impact of these extreme windstorms on buildings and critical facilities, such as schools and hospitals. The SURF student will work with the NIST mentor to mine information from various data sources (e.g., satellite and aerial imagery, NOAA datasets, damage reports, etc.) and contribute to a geodatabase. This damage data will then be analyzed, along with information on the wind hazard, to explore how wind damage varies with wind speed, location, building geometry, and other variables.

Understanding the Role of Polymers in Limiting the Degradation of Solar Panels

The growth of solar power is an important part of the move towards a green energy economy. Large, utility-scale solar farms currently represent the most efficient way to generate electricity from the sun. However, solar panels in large arrays operate at high voltages. At high voltages sodium, a key component of solar glass, can leech out of the glass at the front of the panels and migrate down into the core. Sodium that has traveled to the core of a solar panel contributes to the corrosion of electrical components, degrading solar panel performance, thus reducing the amount of energy that is produced. A polymeric layer, known as the encapsulant, separates the glass from the electrical components of the solar panel. Initial work suggests that improving the polymeric encapsulant layer could limit sodium migration. In this project solar panel encapsulants will be investigated to understand how sodium moves through this polymeric layer. Different polymer/glass samples, exposed to high voltage in a degradation test, will be analyzed to quantify the amount of sodium which has moved through the different polymers. In tandem, the chemistry and structure of the polymers will be characterized to develop an understanding of which polymer characteristics limit sodium movement. With an understanding of how polymer encapsulants can limit sodium migration, new polymers can be designed and implemented to reduce degradation of large-scale solar farms.

NIST Alternatives for Resilient Communities (NIST ARC) Model Development

Hurricanes in 2017 caused a combined $265 billion in damage and resulted in widespread displacement of survivors. The Community Resilience program at NIST provides guidance on planning to reduce the severity of impacts from hazards. This research experience will involve supporting the development of the Alternatives for Resilient Communities (NIST ARC) Model. The SURFer will experience various phases of research, specifically for this project, literature search, model formulation, coding to support and test models, documentation of models, and dissemination of results.

A Technical Landscape Analysis of Efforts to Incorporate Forward Looking Climate Information into the Standards Development Process

The National Windstorm Impact Reduction Program (NWIRP) strategic plan outlines three goals; Understand windstorm processes and hazards, Improve the understanding of windstorm impacts on communities, and Improve the resilience of communities nationwide. The first goal, "Understand windstorm processes and hazards" provides the foundation of NWIRP efforts to inform post windstorm investigations and is designed to develop foundational information of relevance to the meteorological and engineering research communities in support of this goal.

Energy and Environment Division (732)

Graphical User Interface for CYCLE_D Program

The HVAC&R[1] Equipment Performance Group developed and maintains CYCLE_D, a program for simulating performance of refrigerants and refrigerant blends in a vapor-compression cycle. The HVAC&R Equipment Performance Group performs periodic upgrades of CYCLE_D to improve its simulation utility for the refrigeration industry.

CYCLE_D can be installed and used on personal computers capable of running Microsoft Windows. The software package consists of a Graphical User Interface (GUI) written in Visual Basic ver. 6.0 and a thermodynamic cycle simulator module written in FORTRAN. The objective of this SURF project is to assist in a transition of the current CYCLE_D GUI from Visual Basic ver. 6.0 to the Visual Basic.net framework.

Scope: The GUI allows the user to prepare inputs for a simulation run and to display simulation results. The GUI also allows the users to set overall user's preferences for using the program.

The inputs to a simulation run fall into three categories: Refrigerant Selection, Cycle Options, and System Specifications. Simulation results can be displayed on a monitor numerically and graphically, as well as they can be sent to a printer. All these functionalities are coded in individual forms and modules, which will have to be rewritten in Visual Basic.net. It is anticipated that the SURF participant should be able to code the CYCLE_D main window and windows related to the preparation of input data for a simulation run.

The overall goal is to produce a new GUI using the Visual Basic.net platform that will reproduce the appearance and functionalities of the current GUI with some small deviations in design and color selection.

CYCLE_D functionalities and GUI windows are presented in the User's Guide, which can be downloaded from the CYCLE_D website. (https://www.nist.gov/srd/nist-standard-reference-database-49).

[1] Heating, Ventilating, Air-Conditioning and Refrigerating

Milestones

1. Familiarization with CYCLE_D functions and structure
2. Select design variations and color selection for Visual Basic.net modules
3. Code the main window
4. Code and test windows for Refrigerant Selection
5. Code and test windows for Cycle Options
6. Code and test windows for System Specifications

Building Digital Twin Models

The goal of this project is to develop elements of digital twin models for intelligent buildings. Digital twin models are software infrastructure to integrate best practices in computer science, such as knowledge representation, reasoning, machine learning techniques, with other engineering models (electrical, mechanical, architectural). The first step in this project involves developing a Building Information Model (BIM) of a building on the NIST campus using architectural drawings.

Anticipated Milestones:

- Review existing mechanical and architectural drawings of a case study building on campus and identify the missing information
- Conduct walkthroughs in the identified building to fill in missing data
- Develop a BIM model for the case study building (architectural + mechanical)
- Investigate the conversion to IFC (Industry Foundation Class) data models

Desired qualifications, skills, and/or major: Mechanical, civil, or architectural engineering student; Working knowledge of HVAC mechanical system designs, Revit, and/or AutoCAD a must. Working knowledge of Building Information Modeling (BIM) desired.

Building Commissioning Analysis

This project seeks to improve the performance of heating, ventilation, and air-conditioning systems in buildings by identifying and addressing equipment performance faults. The student will help conduct a field validation of the HVAC-Cx building commissioning software, to identify the economic impact on occupant comfort, lifecycle costs, and energy efficiency. The student will work with the NIST advisors to develop and carry out operation monitoring using a combination of functional performance testing and field observations. The student will document findings and contribute to the economic analysis to determine the impact of faults. Historical and new operational data collected from both chilled water and ventilation systems will be analyzed.

Desired qualifications, skills, and/or major: Mechanical, electrical or electronic engineering student; Computer knowledge. Working knowledge of design of experiments and XML.

Design the Controls for a Portable Vapor Compression System Refrigerant Charge Adjustment System or Portable Refrigerant Charge Controller (PRCC).

Two Students Requested

The HVAC&R Equipment Performance Group operates environmental chambers where vapor compressions systems and/or their related components are tested over a wide range of operating conditions. During the testing of residential heat pump and air conditioning equipment, the manufacturer recommended charging method is used to add refrigerant to the system. This procedure begins with evacuating the field assembled components to a high vacuum, adding a mass of refrigerant calculated from the refrigerant liquid line length and indoor coil volume, opening the equipment's service valves to release the manufacturer supplied pre-charge, then using the manufacturers charging method to add and/or remove refrigerant to produce a known refrigerant subcooling or superheat at standard test conditions. Fault testing requires even further manipulation of refrigerant charge to simulate over- and under-charge of refrigerant. An automated method of adding and removing refrigerant charge would greatly speed fault testing and provide a consistent method to set nominal charge at standard conditions.

Milestones

1. Patent search on similar devices
2. Simulate/Emulate a control system based upon written sequences of operations
3. Breadboard and test the emulated control system
4. Test and debug beta version of the PRCC.

Thermoelastic Cooling Exploratory Project

The HVAC&R Equipment Performance Group is responsible for leading cutting-edge heating and cooling research for the benefit of the space conditioning industry. Recently, the Department of Energy (DOE) has identified thermoelastic cooling as the most promising technology for potential further RD&D, with the most "overall importance" by having the highest "potential energy savings and [highest] probability of success" of the 17 alternative technologies that were investigated. A thermoelastic material experiences a temperature change when subjected to compressive forces. In addition, a thermoelastic material is the ultimate low-Global-Warming-Potential (GWP) refrigerant because it's a solid that does not escape into the atmosphere. Presently, our group neither has expertise nor experience with thermoelastic cooling. This project is designed to provide the HVAC&R Equipment Performance Group with introductory experience in the field of thermoelastic cooling. The experience will enable our group to evaluate the potential of entering the field and to be able to write better proposals for sponsors like DOE if entering the field seems promising.

Scope: The scope is described in the following tasks:

Task 1) literature search to define the state-of-the-art for thermoelastic cooling,
Task 2) discussion with the Structures Division for potential test apparatus design,
Task 3) build cost effective test apparatus or borrow/use an existing apparatus from the Structures Division,
Task 4) observe the temperature change of a thermoelastic specimen under compression.
Task 5) write results as a NIST Technical Note.

Milestones

Task 1: Completed literature search

Task 2: Make means for subjecting the test specimen to compressive forces
Task 3: Observe the temperature change under compression
Task 4: Completed technical report.

Fire Research Division (733)

Experimental Measurement of Fire Phenomena and Material Properties Controlling Flammability

A SURF student is requested to help construct, maintain, calibrate, and/or run mg- and bench-scale apparatus (and to analyze the resulting measurement data) used to characterize the thermophysical properties and burning behavior of flammable. Potential applications include prediction of upward flame spread in a parallel panel or wall fire configurations, analysis of the mechanisms of action of engineering technologies to reduce the flammability of residential upholstered furniture, characterization of reference materials for a material flammability database, and measurement of heat release rate of and heat transfer from smoldering embers.

Experimental Measurement of Oxidation of Combustible Solids: Quantifying the Impact of Sample Surface Area on the Kinetics of Oxidative Decomposition

A SURF student is requested to help maintain and run milligram-scale experiments (thermogravimetric analysis, TGA) and numerical simulations for model calibration to determine the kinetics of oxidative decomposition of combustible solids, with explicit considerations for the impact of sample surface area and oxygen availability. A mature understanding of how to characterize the decomposition kinetics of such fuels during oxidative decomposition is necessary in order to advance our fire modeling capabilities and to enable computational predictions of smoldering of fuels (e.g., ignition, continued burning, and flame spread through embers and/or porous fuels, both natural and synthetic).

Development of Experimental Capabilities to Quantify Smoldering Behavior of Embers // Material Response to Smoldering Embers

A SURF student is requested to help construct, maintain, and run bench-scale experiments (and to analyze the resulting measurement data) used to characterize the smoldering behavior of embers (i.e., heat release rate, HRR, and heat transfer) as well as the smoldering propensity of common materials used at the Wildland Urban Interface (WUI), which may be susceptible to attack by smoldering embers. SURF Student will participant in this project as part of a collaborative experimental and modeling effort focused on ember burning behavior.

Fire Model Validation

NIST develops and maintains two computer fire models. One, the Fire Dynamics Simulator (FDS), is a computational fluid dynamics model. Its documentation includes separate verification and validation manuals that describe the results of hundreds of calculations and comparisons to experimental test data or analytical solutions. This database of V&V cases is expanding, and there is a need to incorporate new data and new cases into the repository. The project shall involve working with experimental fire test

data, running numerical simulations, and comparing the results of both. A particular emphasis is on quantifying the uncertainty of the model.

> **Desired Skills:** Computer skills, in particular Matlab, Linux/Unix, Git revision management, Fortran (not a must)

Measurements for Soot Transport to validate Model Predictions

The soot dynamics routines in NIST's Fire Dynamics Simulator (FDS) enable the international fire protection community to predict the effects of soot in a fire, including visibility, tenability, smoke detection, surface deposition and emissions. This project involves conducting experiments in a well-stirred enclosure and in a vertical duct to quantify the soot transport due to gravity and turbulence and particle coagulation. Measurements of surface deposition and size distribution will be compared to FDS predictions, identifying the limitations of the current soot routines and allowing for recommendations for improvement.

Determining the Effect of Fire Barriers on the Combustion Behavior of Cored Composite Products using a Cone Calorimeter

A SURF student is requested to help develop, maintain and run a bench scale apparatus to measure the performance of cored composite products (i.e., composite products including a core acting as the main fuel load and a skin acting as a fire barrier).

Potential impact of the research include analysis of the mechanisms of action of fire barriers, development of fire safe engineering solutions as an alternative to chemical flame retardants for residential upholstered furniture, and lightweight composites materials for building and transportation.

Developing a metric for monitoring the propagation of smoldering combustion

A SURF student is requested to measure the effects of surface area, substrate permeability, sample thickness on the propagation of smoldering for the development of a novel metric to monitor the smoldering propensity of materials such as wood, polyurethane foam, natural and synthetic fibers. Potential impacts of the research include the development of measurement tools for smoldering ignitions in upholstered furniture and WUI applications.

Social Scientific Research of Wildfire Decision-Making

Each year in the US, over 80,000 wildfires burn, of which 2 to 3% spread into nearby communities. These fires force hundreds of thousands of people to evacuate, and damage or destroy approximately 3,000 homes each year. The size and severity of these events, as well as number of deaths attributed to them (e.g., 14 in the 2016 Chimney Tops 2 fire, 22 in the 2017 Tubbs fires, and over 80 in the 2018 Camp Fire) have also increased significantly over the past several years. One way to increase life safety in wildfire situations is to better understand: 1) the types of emergency communications provided to people under imminent threat of a wildfire, and 2) their resulting evacuation behavior, including how they came to that decision.

We are looking for a motivated, organized student who is interested in better understanding communication and decision-making surrounding wildfire safety and evacuation. Projects could include

developing research questions and conducting quantitative (i.e. statistical) analysis of survey data related to household awareness, risk-perceptions, and evacuation decisions from a recent wildfire event, or qualitative analysis of interviews with wildfire decision-makers focused on emergency communication. Outcomes from this research are expected to improve our understand of evacuation decisions and inform wildfire safety and communication techniques.

Students with experience or coursework in statistics or qualitative data analysis is preferred, as well as individuals with coursework or degrees focused in a social science discipline (e.g. sociology, psychology, human geography, behavioral economics, or anthropology).

Systems Integration Division (734)

Development of Tools to Support Geospatial Definitions for Industrial Augmented Reality

In recent years, Augmented Reality (AR) has proven to be a versatile technology that has been leveraged in a multitude of domains including many industrial applications, such as manufacturing planning, assembly guidance, maintenance and repair, among many others. Along with AR's emergence, work from international standards development organizations (SDOs), such as the Khronos Group, Open Geospatial Consortium, and the World Wide Web Consortium, has been fast-paced and very active. However, such SDOs are generally decoupled from standards efforts in the smart manufacturing domain. As a result, utilizing AR toolkits in manufacturing environments remains an expensive, expert-driven, and time-consuming task. Our project is focused on testing AR-based standards in industrial settings to enable quicker, cheaper, and more adaptable AR application development. Our recent focus has been on leveraging geospatial definitions that formally characterizes the geo-locations of objects in an AR scene, specifically focused on production systems. This SURF position will focus on building tools to support the geospatial characterization of industrial scenes

Exploring Methods for Data Wrangling, Visualizing, and Integrating Manufacturing Product Data

The manufacturing industry desires a digital thread of information that aligns different viewpoints of a product. For example, a product designer produces and consumes different data than the manufacturer and this data is not always aligned automatically. NIST has investigated different standard capabilities for integrating data and information between design, manufacturing, and inspection of a product. Through this previous research effort, NIST developed multiple technical data packages (TDPs) containing data from various product lifecycle stages in different standards-based data formats. NIST's Model-Based Enterprise (MBE) Program is seeking a multidisciplinary team of SURF students to explore requirements for wrangling data from various stages of the product lifecycle, visualizing this data for decision making, and integrating datasets across the entire lifecycle. The SURF project will consist of (2) - (4) students across multiple disciplines and having diverse skills from product design, CAD, manufacturing, visualization, scripting skills (e.g. python, R, Matlab), or database development. As this is a multidisciplinary project, it is not expected, nor required, for a student to have skills in each area. Students will gain experience and knowledge related to multiple types of engineering information systems, manufacturing hardware, data formats, and data-driven analysis methods

A Case Study for Modeling Machine Tool Systems Using Standard Representations

A typical Computer Numerical Control (CNC) machining system consists of physical machine tools, material handling devices, control systems, cutting tools, and fixtures. It is challenging to accurately and efficiently evaluate the machining capabilities of machine tools with complex kinematics because of various proprietary formats of different machine component models. This dilemma can be resolved by representing the fully assembled machining tool system in a neutral format such as the STEP standard that can be easily recognized and accepted by all CAx tools. Machine models in standard formats will facilitate the exchange and reuse of machine tool information, models in neutral file formats avoid the remodeling and reconfiguring of this information multiple times for different scenarios. In this project, a case study will be performed to demonstrate the standard representation of a machining system including both machine geometric and kinematics information. An application needs to be developed to extract the kinematic assembly information from the machine model and convert both geometric and kinematics information into the STEP format. This standard-based machine system model will be easily imported to another CAx tool.

Using Category Theory to Accelerate Data integration in Additive Manufacturing Processes

Large amount of data are used and generated from additive manufacturing systems. The data defined and generated by different AM systems are not defined in the same way. Hence, it is very difficult to discover and compare AM builds with similar process settings but built using different AM systems. In this project, we plan to use a new mathematical foundation for AM data integration called Category Theory (CT). CT is the branch of mathematics concerned with modeling and transforming pure structure. CT also has representations for different structures and mappings that can preserve that structure. More specifically, this project is to demonstrate the use of CT constructions to map the process settings from two different AM systems using a tool named Categorical Query Language (CQL) (https://www.categoricaldata.net/). A demonstration will be created to discover builds with similar hatch distance in an AM material database.

Data Registration System Design and Development

The number and types of sensors used for monitoring laser-powder bed fusion processes for metal additive manufacturing are increasing. Each sensor has a unique coordinate system for reporting the collected data. Sensor data fusion becomes issue for monitoring the powder fusion processes and predicting the material properties in the part. The summer research work involves developing some basic statements on describing a software tool for data registration. Functions of the tool include organizing data based on data schemas, establish relationships among related data, and publish the data to a database. Some programming skills are required to develop a prototype.

Optimization of Standardized Methods for Concept Trending with Natural Language Processing Technologies

To best guide our path into the future, we must first clearly see where we've been. Areas of scientific research will evolve and change over time lead both by directions of policy and new

developments in technology. Understanding those trends over time can help predict future areas of focus, help to highlight potential research needs, and identify fertile areas of collaboration across communities that may not traditionally interact and use different expressive language based on their respective domains. There has been recent efforts, particularly in the medical domain, to use Artificial Intelligence and Machine Learning to characterize and synthesize large collections of research publications with implications for guidance, concept searching, and knowledge discovery. The goal of this project is to test, upgrade, and optimize a previously created computer pipeline designed to extract and trend concepts, or areas of interest, from libraries of scientific publications over time. The student will need to have a basic understanding of python and implementing python related packages. Although not a requirement, basic familiarity with any of the following would be also great benefit to potential applicants: Natural Language Processing (NLP), time series modeling, clustering, visualization, or advanced coding methods. NLP technologies are rapidly expanding through many aspects of modern academics, industry, and leisure. Students will gain or increase their familiarity with NLP concepts and derive a solid understanding of developmental testing for research tool development and optimization. The proof of concept data sets will focus on manufacturing related texts, but the skills and any developed tools will have broader applications that could be useful in any domain.

Intelligent Systems Division (735)

Experimentation and Method Development for Health Assessment of Machine Tool Linear Axes

The Prognostics and Health Management for Reliable Operations in Smart Manufacturing (PHM4SM) project is continuing to develop methods to measure the health of machine tool linear axes based on use of an inertial measurement unit (IMU). These methods use IMU data to determine how the performance of linear axes changes with wear as well as the locations of wear. In this project, the student will perform experimentation on a linear axis testbed and develop analytical methods. The student will collect IMU data in LabVIEW for multi-degradation cases, in which trucks or rails are simultaneously worn, and develop analytical methods in MATLAB. The student will also apply machine learning techniques to data collected on a linear axis testbed at a university collaborator facility, for diagnostics and prognostics development and implementation of IMU-based methodology for ball screw health of machine tool linear axes.

Verification and Validation of a Sensor for Robot Workcell Health Degradation Assessment

Robot workcells are becoming more common in a range of manufacturing operations to perform a variety of tasks. As workcell operations vary with changing manufacturing processes, consumer demand, and emergent capabilities, unexpected faults and failures are presenting themselves. NIST's Prognostics and Health Management for Reliable Operations in Smart Manufacturing (PHM4SM) project features a research effort aimed at verifying and validating emerging technologies that can monitor, diagnose, and predict failures at the workcell level where a robot is integrated with other components (e.g., end

effector, fixture). In support of this V&V, the PHM4SM project has developed a novel sensor that complements a test method designed to identify the source of faults or failures across the kinematic chain of a robot workcell. An advanced prototype of this novel sensor has been developed enhancing its output from providing pass/fail data to more granular intelligence about the degradation of a specific element within the robot workcell. Further research is required to verify the functionality of this advanced sensor and validate its implementation within the test method and the overall robot workcell housed at NIST

Interfaces for Human-Robot Interaction

The Collaborative Robotics Laboratory at NIST is exploring new types of interfaces for more natural human-robot interaction in collaborative tasks. These include Virtual & Augmented Reality, tablets, and wearables such as smartwatches. We would like to develop a system to integrate these interfaces with external sensors such as eye tracking and 3D vision, to better determine which parts of the interface & task are most used, and how the interface types change the interaction on the human's part. Additionally, we would like to develop a part tracking framework to observe how the pieces of the task are interacted with. There are only a few selected goals of the project, and the final project can be adjusted to the student's interests. (Please note that details of this project are subject to change.)

Vision-Based Smart Target Development to Support Robot Accuracy Degradation Assessment

Manufacturers currently struggle with machine/robot's accuracy degradation assessment and accuracy improvement that limits the efficiency of machine/robots in high precision applications. Current best practice in the industry is to inspect the final products or add redundancies (local calibration etc.) during the process. These create the complexity in process and increase the maintenance costs to high leverage applications such as high precision robot operations (welding, robotic drilling/riveting, and composite material layout), in-process metrology, and machine in mobile applications. What they need is higher speed, more precise control of position and orientation. A novel smart target was designed at NIST to integrate with a vision system to acquire high-accuracy, real-time 6-D (six-dimensional x, y, and z position, roll, pitch, and yaw orientation) information. The smart target development is also a part of the Prognostics and Health Management for reliable operations in smart manufacturing (PHM4SM) research at NIST. The PHM4SM project works on developing and deploying measurement science to promote the implementation, verification, and validation of advanced monitoring, diagnostic, and prognostic technologies to increase reliability and decrease downtime in smart manufacturing systems. In this project, the smart target technology will be developed to assess the robot accuracy degradation. The student will help to develop a software tool with graphic interface for the dual-camera system to measure the smart target and output 6-D information and perform experiments to capture various target poses when robots moving with the smart target.

> **Required Qualifications/Skills:** Skills in programming (e.g., C, C++, and Python) (required), knowledge of image processing and analysis (desired), skills in MATLAB (desired), skills in GUI development, software development, and debugging.

Performance Benchmarking of Robotic Hands Ability to Sense Slip

With a growing number of robot hands, there is an increasing need to capture their individual competencies and characteristics under a unified framework. In addition to knowledge of basic hand

characteristics such as the number of fingers, degrees of freedom, and degrees of actuation, performance metrics can provide valuable insight into not only the raw traits of the technology, but also their task and function-level performance capabilities. These measures can then be used to help to match capabilities to end-user needs as well as to help provide researchers and developers insight for improving their hardware and software designs. This project will explore performance metrics and test methods for robotic hands equipped with tactile sensors and their ability to sense force and resist slipping of grasped objects under increasing external forces.

Milestones:

- Perform a literature search of techniques of sensing slip using a tactile sensing technology.
- Write algorithms for a robotic hand to grasp objects and modulate grasp force based on sensory feedback from tactile sensors to detect both force and slip.
- Develop a test method using standard shaped objects and an actuated device apply increasing forces to grasped objects to test the performance of
- Present finding and results to SURF peers.

Qualifications/Skills: Undergrad in ME or CS, MATLAB and/ or a high-level programming language (C++, Java)

Develop methods to measure and identify optimum gas flow for laser powder bed fusion.

In metal additive manufacturing with laser powder bed fusion, gas flow in the build chamber can have important impacts on the process. Poor flow allows accumulation of condensate and ejecta, which may distort or block the laser beam leading to poorly controlled melting and defects in the built part. Therefore, NIST is looking to develop measurement approaches to determine best practices for measuring gas flow and what gas flow velocity profiles are appropriate for laser powder bed fusion. The student will perform hot wire anemometry measurements to characterize the gas flow in various places, under various conditions, within a commercial laser powder bed fusion additive manufacturing machine at NIST. The student may also perform microscopy of cross-sectioned laser-melted samples, and image analysis of inline process monitoring data to understand how changes in gas flow might change part properties. The student will fully document the measurement method and lessons learned, and propose potential improvements or next steps for further measurements in other laser powder bed fusion systems.

Automated Door Opening using AI, 3D Sensors, and Mobile Robots

Emergency Response Robots are used in situations that are dangerous for humans. Opening the door of a suspicious vehicle is a challenging tele-operation task for humans. Robots could learn to open vehicle doors autonomously. The NIST "AI for Door Opening using Robot Manipulators" project is exploring machine learning (ML) techniques in order to teach a mobile robot to open vehicle doors using various sensing technologies. NIST is interested in researching different techniques including teaching by demonstration using actual doors and instrumented humans, unsupervised learning, learning through demonstration in VR and AR, learning through simulation using real world data, etc.

Software Integration of a Web-based Robot Interface

The Sawyer robot is a collaborative arm by Rethink Robotics which comes with a browser-based graphical user interface, Intera Studio. This interface can be accessed on the robot's screen or on an external computer but does not allow for text-based programming while in factory mode. We would like to integrate the Sawyer with the Collaborative Robotics Programming Interface (CRPI) developed by NIST. The goal of the project is to emulate the commands sent to the robot from Intera Studio and create a software interface that can communicate with and control the robot.

Probabilistic damage tolerance analysis for additive manufacturing

Additive manufacturing (AM) enables creation of complex features with reduced weight. Biomedical and aerospace industries are interested in adopting AM for critical components. The lack of information on defect detection capability and fracture probability, however, is inhibiting wider adoption. Probability of detection (POD) curve estimates defect detection capability of a non-destructive evaluation system. Probabilistic damage tolerance analysis incorporates variables such as anomaly distribution, POD curves, residual stress, and crack growth rate to predict probability of fracture. A case study will be performed by designing an AM part, determining a POD curve, and estimating probability of fracture.

Fiducial Design for Surface Analysis of AM Fatigue Specimens

The goal is to develop and test fiducial markers on additively manufactured (AM) fatigue specimens for use in pre/post fracture surface characterization. Currently, there is little known about the effect of the as-built AM surface and intelligent design of fiducial markers will be required to accurately relate pre and post fatigue test surfaces. The student will work with the group's machinists and the machine shop to design various fiducial markers on the fatigue specimens, investigate the uncertainty of measurements using an optical focus variation microscope (FVM) and x-ray computed tomography, as well as the limitations of the various measurement systems.

Destructive Surface Analysis of AM Parts

The goal of this work will be to investigate the use of destructive surface analysis to determine uncertainty of optical (non-destructive) surface measurements on parts fabricated by additive manufacturing (AM). Currently, understanding of the uncertainty of optical surface topography measurements on surfaces such as those built by AM is limited. One method hypothesized to improve that understanding is to use destructive methods to section the part for measurement with a standard optical image microscope. The student will work with NIST staff to optimize and carry out a measurement routine, as well as perform the post measurement data preparation and analysis.

Exoskeleton Survey Analysis

Exoskeletons are becoming useful in industrial, medical, response, military and even recreational applications. The NIST research team has tested subjects performing potentially standard tasks. Surveys have been completed by over 30 people who have performed tests while not wearing and while wearing exoskeletons. Upon test completion, the subject filled out a survey about the exoskeleton and the test method. This data requires analysis to uncover aggregate results across all subjects to find

correlations to gender, height, fatigue, and other metrics that can help improve exoskeletons, exoskeleton test methods, and to lower risk to humans wearing exoskeletons to complete tasks.

Wearable sensors for human-robot interaction

Human-robot collaboration in manufacturing settings are largely driving by the safety concerns associated with the close proximity and potential contact with industrial robots, tooling, and process-based hazards. A leading contributor to these safety concerns is the uncertainty associated with human position, actions, and intent. Advanced sensor suites are required to monitor the human while in the collaborative work zone, but are prone to interference and measurement error given the unstructured nature of human-robot interaction. This project focuses on the development of wireless, wearable sensors that can be used to facilitate natural movements while in the collaborative work zone without compromising sensing performance, process efficiency, or safety.

Evaluation of Exoskeleton fit

Exoskeletons are becoming common place in industry. Factories, like Toyota are make exoskeletons required PPE in some applications on the assembly line. NIST researchers are developing Standard Test methods and measurement science towards comparison of results in which to evaluate the capabilities of the systems.

Designing a Sensor Board and Interface for Stretchable Electronics

Exfoliated intercalated graphite composite sensors are highly deformable making them ideal for flexible sensors, soft robots, and wearable applications. Currently, the sensor boards reading the sensor response are bulky, making close packing of the sensors difficult. The sensor boards can be redesigned to reduce their footprint. This project focuses on the redesign of this sensor package to achieve markedly reduced footprints without compromising sensing performance. Specific process-oriented goals also include 1) to apply the required pressure needed to maintain good contact with the capacitor, 2) to reduce the time and effort required to facilitate sensor assembly, and 3) to improve the sensor yield and lifetime.

Optimization of Standardized Methods for Concept Trending with Natural Language Processing Technologies

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applicants: Natural Language Processing (NLP), time series modeling, clustering, visualization, or advanced coding methods. NLP technologies are rapidly expanding through many aspects of modern academics, industry, and leisure. Students will gain or increase their familiarity with NLP concepts and derive a solid understanding of developmental testing for research tool development and optimization. The proof of concept data sets will focus on manufacturing related texts, but the skills and any developed tools will have broader applications that could be useful in any domain.