Summer Research Institute (SRI) 2020
Virtual Program
Student Team Project Descriptions

Student demographics:

23 students (21 undergraduate / 2 graduates)
48% students from underrepresented communities (women/minority)
12 academic disciplines
5 universities represented (Boston University, City College of NY, Montclair State University, Stevens Institute of Technology and Texas Southern University)

Student 2Team Research Projects:

Sulfur Emission Detection

Faculty Mentor: Dr. Bruce Kim -Visiting Faculty -City College of NY

Description: Under the aegis of the United Nations International Maritime Organization (IMO), regulations have been developed to limit polluting emissions from ships. They include sulfuric, nitrous, and particulate emissions. The United States Coast Guard (USCG) has the responsibility of enforcing these regulations in US waters. At the present time, USCG capabilities to measure these pollutants are inefficient. Furthermore, the IMO has recently implemented a global cap on sulfur emissions from 3.5% to 0.5% as of January 1, 2020. In this project, we propose to apply nanotechnology techniques to develop a sensor that can efficiently detect and measure sulfur content in ship emissions. This task includes continuous research and development of novel probing methods and detection techniques for identifying and measuring sulfur emissions produced by ships using diesel fuels. The project aims to develop a Zinc Oxide (ZnO) nanowire array-based sensor platform capable of remote operation. The project will be performed remotely, the faculty and student team will leverage a number of online modeling and simulation tools, as well as mechanical engineering and chemical engineering software packages to develop a proof of concept for sulfur emission detection. The project will include frequent web-based meetings and remote collaboration among the members of the team and faculty advisors, and the entire SRI student group.

Risk Management Dashboard and Predictive Analytics

Faculty Mentors: Dr. Talmor Meir, Verisk Analytics and Dr. Barry Bunin, Stevens Institute

Description: The USCG maintains a large data base of information pertaining to maritime safety, security, and law enforcement incidents. These incidents include vessel collisions or near collisions, pollution, breach of security and so forth. The data base is referred to as the MISLE (Marine Information for Safety and Law Enforcement) system. Information is entered into this system by operations officers on a nationwide basis. Although this information may provide valuable insights into risk areas and subsequent risk management initiatives on a national level, it is not analyzed to permit effective risk management on a port specific operational level. In this task, students will build upon a Risk Management Dashboard completed during the SRI 2019 program. This summer's project will include improving the design and functionality of the Dashboard and to include new pertinent data sets and predictive analytics capabilities. The project will consist primarily of a computational study, with the aid of an existing prototype. The project will include frequent web-based meetings and remote collaboration among the members of the team, including weekly consultations with the faculty advisor and the entire SRI student group.

Maritime Cyber Risk – Risk assessment comparison between Information Technology (IT) and Operational Technology (OT) Vulnerabilities

Faculty Mentor: Dr. Barry Bunin, Stevens Institute

Description: Traditionally, cyber-attacks have been focused on the internet and its IT infrastructure. The capabilities provided by this IT include email, web access, and data base access for personal information and corporate management. Example attacks may be phishing for personal information, man-in-the-middle attacks for redirecting communications, and malware for damaging and disabling systems.

The widespread digitization of the Operations Technology (OT) controlling physical processes, such as the distribution of electric power over the power grid, or the navigation and propulsion systems on ships, can provide significant operating efficiencies. These efficiencies can be achieved through the remote sensing and control of the OT. Since this remote access may be achieved by internet access and its IT, the OT is more vulnerable to attack. An example of a debilitating IT attack is the 2012 Saudi Aramco Shamoon attack. An example of a destructive OT attack is the Stuxnet virus attack on an Iranian uranium enrichment plant in 2010.

In this project, a literature search will be conducted to catalog as many as possible relevant cyber-attacks on industry, maritime, and national infrastructure. The methodology of these attacks will be determined, as well as an assessment as to whether these attacks were on the IT or OT (or both) infrastructure. Then using an accepted model, the consequences of these attacks will be determined, and a qualitative risk assessment made. The project will consist primarily of an extensive literature review. The project will include web-based meetings and remote collaboration among the members of the team, including weekly consultations with the faculty advisor and the entire SRI student group.

Off-Shore Windfarm Safety and Security Issues

Faculty Mentor: Dr. Barry Bunin, Stevens Institute

Description: Wind energy is necessary to help meet the nation's renewable energy needs. Windfarms have been deployed around the world and there are currently 15 offshore wind energy projects within the Mid Atlantic of the United States with plans for the southeast and west coast as well. These wind farms consist of large towers equipped with rotating vanes which drive turbines to generate electricity. Wind farms can contain hundreds of such towers and span hundreds of miles. They may also include booster and reactive compensation stations for efficient transmission of power over longer distances from wind farm to shore. These installations, due to their large metal towers and rotating vanes, can interfere with radio transmissions in various ways, and therefore impair Coast Guard Search and Rescue operations in their vicinity. Helicopter search paths occur at 500 feet elevation and the heights of the turbines are now exceeding this threshold. In addition, the presence of hundreds of towers may alter ocean currents in terms of their direction and speed, and in turn, affect predictive ocean models used to locate distressed parties that drift with the current. Furthermore, these wind farm structures may interfere with the radar systems used to measure current direction and speed for use in oceanographic models as well as for detecting target vessels and other vessels in the vicinity.

There have been many studies of the effects of these wind farms on navigation, radio interference, ocean currents and other environmental considerations. In this task, students will perform a literature search of relevant publications, and develop a set of important effects, and any proposed mitigation of these effects. Based on these, the team will develop possible impacts on Coast Guard operations, and suggest possible regulations to minimize these effects. The project will include frequent web-based meetings and remote collaboration among the members of the team, including weekly consultations with the faculty advisor and the entire SRI student group.

BlueROV: ***Efficient Deployment and Monitoring of an Advanced Harbor-Inspecting Underwater Robot***

Faculty Mentor: Dr. Brendan Englot, Stevens Institute

Description: Stevens Institute of Technology's Robust Field Autonomy Lab has developed an advanced underwater robot prototype, based on the widely-used BlueROV platform, capable of autonomous 3D sonar-based mapping of underwater structures. The robot can be used to inspect piers, bridges, and ships, and its 3D maps will support anomaly detection. It is desirable for the robot to be easily deployed and recovered by one to two people in port and harbor areas and for its operators to easily monitor the robot's progress and obtain situational awareness of the environments the robot is inspecting.

Team members will design, fabricate and test a launch-and-recovery device to enable safe and efficient deployment of the BlueROV, as well as contribute to the software tools used by human operators to monitor the robot's progress. The BlueROV collects large volumes of sonar data from different perspectives, and the team members will design, implement and test an intuitive user interface that improves a human operator's situational awareness as they monitor the robot's progress during an autonomous inspection. Both the hardware and software components will be tested throughout the summer during outdoor deployments of the BlueROV on the Hudson River and in other regional harbor environments. The project will emphasize the mechanical design of a portable and easy-to-manufacture launch-and-recovery system for the BlueROV, and the work on user interface design can proceed using the large quantity of existing BlueROV data-sets that are available and will be shared with members of the team. Frequent web-based meetings and remote collaboration would be performed by the members of the team, including weekly consultations with Stevens PhD students, the faculty advisor and the entire SRI student group.

Wave Glider: ***AI-Enhanced Design and Digital Twinning of an Unmanned Surface Vehicle***

Faculty Mentor: Dr. Brendan Englot, Stevens Institute

Description: Can the tools of artificial intelligence be used to inform engineering design? This question will be addressed in the context of designing an unmanned surface vehicle (USV) capable of transiting the ocean while consuming net-zero energy, relying upon renewable forms of energy such as wind, waves, and the sun. Such a vehicle would be capable of surveying and monitoring coastal environments for very long durations without human assistance or intervention. The team members will explore whether learning from exemplary "seed designs" of energy-harvesting vessels (such as sailing vessels and wave gliders) is capable of supporting the generation of novel high-performance designs that contain new combinations of traditional marine system components, which perhaps harvest multiple forms of energy using a single vehicle. In addition to considering the vessel's forms of energy-harvesting, the team will also consider its perception, navigation, and control, leveraging USV simulation tools to explore the performance and maneuverability of candidate designs. Ultimately, it is desired to produce a "digital twin" of the resulting USV, which can be used to simulate its performance and operation with high fidelity. This project work will consist primarily of a computational study, performed with the aid of simulation tools. The student team will engage in frequent web-based meetings and remote collaboration, including weekly consultation with Stevens PhD students, the faculty advisor and the entire SRI student group.