Department of Homeland Security Scientific Leadership Award Program (DHS-15-ST-062-001)

Preparing Technically Savvy Homeland Security Professionals for Maritime Transportation Security

AWARD NUMBER: 2014-ST-062-000057-02

Final Report

Prepared by

TSU DHS SLA Team

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TABLE OF CONTENTS

Chapter 1: INTRODUCTION

1.1 Goal and Objectives

Texas Southern University's DHS SLA program was launched in September 2014. This program aims to foster and broaden TSU's existing Bachelor of Science program in Maritime Transportation Management and Security through interdisciplinary undergraduate research and education. The goal is to increase the Pipeline of Science, Technology, Engineering, and Mathematics (STEM) majors in MSI for Maritime Transportation Security through interdisciplinary Undergraduate Research and Education.

To achieve this goal, this education program has the following three specific objectives:

- Develop an integrated research and education program to provide innovative technology solutions for the Homeland Security Enterprise (HSE), particularly for maritime transportation security.
- Develop an interdisciplinary undergraduate curriculum to prepare a technically savvy workforce in Maritime Transportation Security.
- Increase the number and quality of students who graduate in a STEM discipline within Minority Serving Institutions (MSI).

These three objectives have been achieved in two phases and the focus of each phase is described in the following Figure 1.

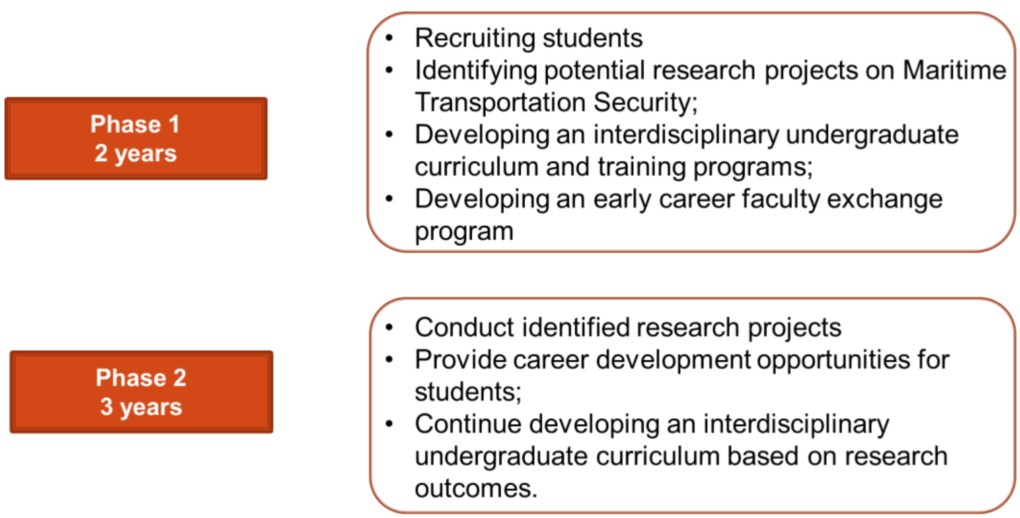

Figure 1-1: Project Objectives in Two Phases

1.2 Teams

TSU has assembled a team with great diversity to work on the DHS SLA program. Faculty and staff from 4 different departments in the College of Science, Engineering, and Technology (COSET) were working on the TSU DHS SLA program. They are the Department of Transportation studies, the Engineering Department, the Computer Science Department, and the Mathematics Department. The following are the key personnel of this program.

Dr. Yi Qi,
Professor and Chair,
Transportation Studies,
PI and Program Director

Ms. Ursurla William,
Visiting Instructor,
Transportation Studies,
Program Coordinator

Capt. Robert Morgan,
Visiting Instructor,
Transportation Studies,
Co-PI

Dr. Mehdi Azimi,
Assistant Professor,
Transportation Studies,
Co-PI

Dr. Yunjiao Wang,
Associate Professor,
Mathematics,
Co-PI

Dr. Sahin Ismet,
Assistant Professor,
Engineering Technologies,
Co-PI

Dr. Pan Miao,
Assistant Professor
Computer Science,
Co-PI

Ms. Qun Zhao,
Research Associate,
Transportation Studies,
Researcher

1.3 Structure of the Report

Chapters 2-4 report the achievements our team made for the three objectives. Chapters 5 and 6 introduce the collaborations with DHS COEs and other partners respectively. Finally, Chapter 7 listed the major program achievements.

CHAPTER 2: RESEARCH

The first objective of this program is to develop an integrated research program to provide innovative technology solutions for the Homeland Security Enterprise (HSE), particularly for maritime transportation security. Three research topics have been identified, which are:

1. Maritime Risk Assessment and Management
2. Maritime Cargo Security: Data Analysis and Intelligent Screening
3. Secure and Efficient Maritime Data Storage and Retrieval

2.1 Maritime Risk Assessment and Management

Despite mandates by the International Maritime Organization (IMO) and the U.S. Coast Guard to perform regular risk assessments at ports, onboard ships, and at the office, to verify how incidents, accidents, injuries, or near misses are caused, companies are frequently reluctant or unable to identify potential risks, thus imposing a threat to their own systemic integrity. This project examined the industry's practices and the identification of systemic failures, with the purpose of significantly improving corporate risk management and risk-assessment practices. It established a systemic platform for the maritime industry by modeling and analyzing risk assessment and management. It developed and validated the industry's regulatory requirements and standards by employing established, measurable, and demonstrable measures that will improve the prevention and vulnerability reduction measures in the shipping industry. The results of this research project enhance the efficiency and functionality of the safeguard systems of the present maritime infrastructure.

Capt. Morgan was the main investigator on this topic. He and his student research assistants finished the following tasks:

Task 1: Literature search

Task 2: Literature review: Analyze and synthesize the reviewed literature

Task 3: Synthesize the Methods and Measurements for Maritime Risk Assessment and Management

Task 4: Document Research Findings

The final report is attached as Appendix I.

2.2 Maritime Cargo Security: Data Analysis and Intelligent Screening

Given the extensive economic importance of the maritime supply chain, the vulnerability of maritime cargo to smuggling, terrorist attacks, and other malicious attacks has long been a concern, especially after the events of 9/11. Since there are approximately 11.6 million maritime cargo security containers entering U.S. ports each year, an efficient screening model should be constructed, and the U.S. CBP needs effective tools to facilitate screening instead of the traditional screening by hand. This project investigates the potential application of data mining techniques to create an intelligent screening model in order to strengthen maritime cargo security. The researchers identified the important cargo attributes and then, developed a model and screening process. The model can be employed to build up a risk-based screening classifier by employing the identified attributes as well as the CBP historical data as training data. The model proposed in this research has the potential to be used in a software prototype, which could provide an effective, efficient, and feasible approach to the screening of U.S.-bound cargo. When new cargo containers enter a port, the CBP just needs to input some attributes of the cargo into its online portable devices (e.g., tablet, iPad, smartphones, etc.), assess the risk of the cargo, and single out high-risk cargo for further inspection. The procedure will result in enhancing the security and prosperity of the maritime supply chain.

Drs. Mehdi Azimi and Miao Pan were the main investigators of this research topic. They successfully finished the following tasks:

Task 1: Review of literature

Task 2: Conduct a questionnaire survey to identify cargo attributes

Task 3: Model the screening process, and selecting a machine-learning algorithm to be applied in building up a screening classifier

Task 4: Evaluating screening classifier criteria

Task 5: Document research findings

The final report is attached as Appendix II.

2.3 Secure and Efficient Maritime Data Storage and Retrieval

Due to the massive amount of maritime cargo containers entering U.S. ports, it costs too much to store all the cargo records in the servers at local ports (e.g., the cost of adding servers, data maintenance costs, the cost of server specialists, etc.). One way to effectively reduce these costs is to centralize all maritime data in large data centers, i.e., the cloud. However, when a maritime computer system is connected to the Internet, the system becomes available to its administrators and users but also malicious attackers. The objectives of this project are to 1) research new ways of increasing the security of data access and modification in marine systems without reducing the efficiency of network applications; 2) develop a new course on marine cybersecurity.

Drs. Ismet Sahin and Miao Pan were the major investigators for this research project. They performed the research following the seven steps:

1. Literature review on methods used for identifying phishing attacks and proposed approaches for protecting computer systems
2. Dataset
    a. Find a dataset that includes instances of malicious and benign web addresses
    b. Read the features of all examples (instances) and their labels into the Matlab programming language environment
3. Improve the stochastic optimization methods based on taking steps in different directions with different step sizes
4. Implement neural networks using the K-Nearest Neighbors (KNN) algorithm, and Neural Network (NN) algorithm

5. Implement neural networks with improved stochastic optimization algorithms and compare the results with those obtained in step 4
6. Develop a course that aims to teach students about maritime cybersecurity principles.
7. Write and submit a manuscript to a journal

The final report is attached as Appendix III.

CHAPTER 3: EDUCATION

3.1 Develop New Interdisciplinary Courses

Developing an interdisciplinary maritime undergraduate curriculum is the second objective of the TSU DHS SLA program. As proposed, 5 new interdisciplinary courses have been developed, including:

- New course 1: Software for Scientific Computing (online),
- New course 2: Introduction to Operations Research (online),
- New course 3: Introduction to Maritime Cybersecurity,
- New course 4: Maritime Big Data Analytics and Security,
- New course 5: Maritime Risk Assessment and Resiliency Analysis.

3.1.1 New course 1: Software for Scientific Computing (online)

The purpose of this course is to improve mathematical modeling skills and MATLAB programming skills for students in the Maritime Transportation Security program. It will develop students' computation ability through a sequence of projects on numerical methods, mathematical modeling, and simulations.

This course has been well developed by Dr. Yunjiao Wang from the Department of Mathematics. All lecture notes and some lecture videos have been uploaded to the Blackboard (an online learning management system). Materials available on Blackboard include:

- Syllabus
- A complete set of lecture notes and programming codes
- A complete set of Assignments
- A complete set of Quizzes and Exams
- A completed list of lecture videos

In FY2020, New course 1: Software for Scientific Computing (I): a statistical analysis using R has been approved by TSU and is in course inventory as Math 232.

3.1.2 New course 2: Introduction to Operations Research (online)

Students involved in the study and research of Maritime Transportation Security are required to have the ability to model and analyze problems optimally using limited resources. This course, ***Introduction to Operations Research*** provides students with the tools for modeling and analyzing such problems. The course is focused mainly on linear programming and its applications. The course aims to provide students with knowledge and skills in formalizing and analyzing linear programming problems.

This course also has been successfully developed by Dr. Yujiao Wang. Course syllabus, all lecture notes, and some lecture videos are available on Blackboard.

In FY2020, New course 2: Introduction to Operations Research has been approved by TSU and is in course inventory as Math 252.

3.1.3 New course 3: Introduction to Maritime Cybersecurity

This course provides information regarding the procedures and methods necessary to assess threats, vulnerability, and consequences of all facets of maritime risks, as well as strategies to prevent these risks and minimize their consequences. By taking this course, students will understand the factors affecting the security of the port and maritime operations, including risk management, risk assessment, shipping, politics, economics, crime, piracy, and terrorism. They will review the vulnerabilities in today's practices; evaluate proven and tested recommendations that recognize the role and interests of both government and the private sector in enhancing security and risk management while ensuring the flow of international trade.

The course has been successfully developed by Dr. Sahin Ismet from the Department of Engineering Technologies. The following materials have been completed and uploaded to Blackboard:

- Full Syllabus with detailed week-by-week agenda
- 10 Lectures
- 12 PowerPoint slides
- 15 Discussion Questions
- Instructions for the students for posting to the “Discussion Question” section.

This course was proposed to the TSU Curriculum Committee and was accepted in December 2018 and is in course inventory as MTMS 448.

3.1.4 New course 4: Maritime Big Data Analytics and Security

Big data is the study and applications of data sets that are too complex for traditional data-processing application software to adequately deal with. Even though big data has significantly benefitted industries such as finance, media, telecom, and healthcare, its uptake by the maritime industry has been slow. This was one of the motivations that encouraged us to design the course “Maritime Big Data Analytics and Security”. Dr. Mehdi Azimi from the Department of Transportation Studies did a comprehensive literature review on big data in the maritime sector and summarized useful information to be added to the new course. The materials include a look at how and where the technologies are being implemented and the key application areas that will deliver future operational efficiencies for ports and terminals. The study also explored some of the key barriers to change, such as investment and skills, and how to overcome these challenges. In summary, new topics are as follows:

- Current and potential application areas for big data in the maritime industry
- Examples of big data technology implementation in ports and terminals
- Big data analytics to improve maritime security
- The future of big data in the maritime industry

- Key trends and initiatives in the use of big data in the maritime industry
- Key challenges faced in the adoption of big data by the maritime industry.

In FY2020, Dr. Azimi finalized the syllabus and course content for the new undergraduate-level course "MTMS 447 – Maritime Big Data Analytics and Security" and submitted it to the curriculum committee university for approval.

3.1.5 New course Maritime Risk Assessment and Resiliency Analysis

This course is to provide students knowledge regarding the procedures and methods necessary to assess threats, vulnerability, and consequences of all facets of maritime risks, and strategies to prevent these risks and minimize their consequences. To develop this new course, Capt. Morgan from the Department of Transportation Studies examined security measures and practices applied in the industry, namely the movement of cargo both at the port and throughout the transportation logistics process. He compared the potential, tools, and technologies utilized. In addition, the findings from his research project were also been incorporated into it.

Professor Capt. Morgan has accomplished the following tasks pertaining to the implementation of the new online course, *MTMS 446 Maritime Risk Assessment and Resiliency Analysis*.

- The TSU Online Instructional Designer approved the completion of the subject course for the Fall2018 semester on August 17, 2018.
- Completed a comprehensive syllabus in accordance with the new syllabus format is required by Texas Southern University's new policy for online courses.
- Developed 15 detailed Discussion Questions requiring extensive research from the students.
- Engineered three major assignments papers requiring a maximum of 600 words based on extensive research supported by scholarly citations.
- Created 15 lectures from various research including scholarly writings, collaborations with various legitimate security agencies, and actual visits to several DHS facilities.
- Formulated several PowerPoints, videos, and included several textbooks to help the students in understanding the fundamentals of Risk Management, Risk Analysis, and Resiliency.
- Began the instructions of the new online course on August 27, 2018 with an enrollment of 18 students.

This new course, MTMS 446 Maritime Risk Assessment and Resiliency Analysis, has been approved by TSU Curriculum Committee in January 2017 and has been offered to Maritime program students since Fall 2018.

3.2 Update Security-related Courses for the Maritime Program

Besides newly developed courses, 4 existing security-related courses for the maritime program have been updated by integrating the research findings from this program, including:

- MTMS 341 - Maritime Security Management,

- MTMS 342 - Maritime Security Technology,
- MTMS 424 - Containerization and Modern Cargo Storage,
- MTMS 443 - Maritime Transportation Security.

3.2.1 MTMS 341 - Maritime Security Management

MTMS 341 Maritime Security has been first improved by Capt. Morgan immensely through collaboration with other government agencies such as the Port of Houston Authority and various supply chain management organizations. The following is the list of various improvements, which also have been developed to PowerPoint slides for this class.

- Maritime Safety and Security
- Marine Terminal Safety and Security
- Shipboard Safety and Security
- Maritime Security Port of Entry and Documentation Requirements
- Maritime Security Management
- Maritime Security Agencies
- The Role and Mission of the USCG
- Personal Security
- Houston Ship Channel Security District
- Vessel Tracking System
- Ethics and the Human Elements in Maritime Security
- Pirates and Piracy: Past and Present

Dr. Mehdi Azimi also continuously improved this course. A lecture in the format of a PowerPoint presentation was designed and uploaded in the course blackboard. For some lectures, additional handouts from external sources were also selected and uploaded to help the students better understand the topics taught in those lectures. Furthermore, short videos related to some topics were selected to play at the end of the lectures. Moreover, related articles from magazines, publications, trade journals, and newsletters within the technology industry are read and discussed with the students during the classes. The course materials are accessible to the students through the university blackboard system.

3.2.2 MTMS 342 - Maritime Security Technology

This course explores the implications and consequences of scientific and technological issues in terms of maritime security in a social and political context. It presents instructions and discussions on current security issues and technologies. Dr. Mehdi Azimi conducted a thorough literature review and interviews with port authorities and updated this course.

3.2.3 MTMS 424 - Containerization and Modern Cargo Storage

This course presents the principles and regulations for transporting special refrigerated and hazardous cargo. It addresses the security of shipments from a regulatory, operational, and global business perspective. Dr. Mehdi Azimi improved this course by incorporating the results of the research he conducted into the existing course materials.

3.2.4 MTMS 443 - Maritime Transportation Security

This course has been continuously improved by Dr. Mehdi Azimi. For each session of the class, a lecture in the format of a PowerPoint presentation was designed and uploaded in the course blackboard. For some lectures, additional handouts from external sources were also selected and uploaded to help the students better understand the topics taught in those lectures. Furthermore, short videos related to some topics were selected for some lectures. Moreover, related articles from magazines, publications, trade journals, and newsletters within the technology industry are read and discussed with the students during the classes.

In addition, some new topics, such as Drug Smuggling via Maritime Cargo/Containers/Vessels, Port Security Management, Threat Mitigation Strategies, and Information Security and Assurance, were added to it.

3.3 Develop Training Programs

3.3.1 DHS SLA Seminar Series

Since the FY2015, the TSU DHS SLA program designed and organized a series of seminars on various topics of homeland security. These seminars not only expose students to knowledge outside their classroom but also provide network opportunities with industry experts.

Table 3-1 Summary of Organized Seminars

Year	No. of Seminars	Topics
FY2016	1	"Management and Leadership in Your Career"
FY2017	2	"Securing the Port of Houston Lecture" "The Future of National Security – Maritime Cybersecurity"
FY2018	2	"Border Security-Past, Present and Future" "Environmental and Technological Risks. Creating a Shared Future in a Fractured World"
FY2019	3	"Mitigation Strategies for Potential Maritime Transport Cyber Security Issues" "Domestic Federal Security Regulations" "Maritime Industry and Cybersecurity"
FY2020	1	"Resilience of Ports and the Marine Transportation System"
TOTAL	**9**	

The following are the flyers of the organized seminars.

Figure 3-1: Flyers of All DHS SLA Seminars

3.3.2 Fast Forward Workshop

Fast Forward Workshop is a one-day training event designed to focus on leadership and soft skills training that the students may not receive in a traditional classroom setting. Workshop topics included: Effective Communication Strategies, Leadership 101, Professional Communication Skills, Leading with Excellence, Conflict Resolution, and Dealing with Change. Speakers have been invited include:

- Capt. Marcus Woodring, the Port of Houston Authority
- Mr. Jeff Baldwin, President, Baldwin Liaison Consulting, LLC; (Retired) Senior Executive, CBP Field Operations, Department of Homeland Security
- Dr. Johnella Bradford with Houston Community College

- Mrs. Dawona Miles with the Port of Houston Authority
- Dr. Bradford, Director of Transformation and Innovation Center at Houston Community College
- Rod Hudson, the U.S. Customs and Boarder Protection
- Mr. Bonar Luzey, II, Security Consultant, Alvarez & Marshall
- Ms. Jacquie Young-Hall, Maritime Education Program Coordinator, Port Houston
- Mr. John Hark, Chartering Director of Bertling Logistics, Inc

Following Figures are selected photos were taken during this yearly event.

Figure 3-2: Fast Forward Workshop 2017

Figure 3-3: Fast Forward Workshop 2018

Figure 3-4: Fast Forward Workshop 2019

3.3.3 Maritime Certificate Courses

<u>Maritime Port Management (MPM) and Maritime Port Executive (MPE) Certification Programs</u>

August 12, 2020, TSU signed an MOU with the International Association of Maritime and Port Executives (IAMPE) for the Certification Programs: Maritime Port Management (MPM) and Maritime Port Executive (MPE) at TSU.

IAMPE is one of the most important ports and maritime educational industry associations in North America, and these two certifications are well recognized by the maritime field and have been endorsed by some major ports and higher education maritime institutes, including Loeb-Sullivan School of International Business and Logistics at Maine Maritime Academy and the Graduate Program at Massachusetts Maritime Academy.

According to the signed MOU, an MPE Program will be hosting at TSU campus for up to 15 participants plus TSU participants annually. In addition, TSU transportation planning and management program would accept the 36-hour Maritime Port Executive (MPE) certification program to substitute a 3-credit elective course TMGT 827 “marine transportation systems” for anyone who completed the MPE program and take an additional assignment. In exchange, TSU faculty members, students, especially maritime students will receive the following benefits:

1. Certification of TSU students as Maritime Port Managers (MPM) for those completing a curriculum accepted by the IAMPE Board of Advisors in the TSU master’s program.
2. Certification of TSU students as Marine Terminal Operators (MTO) for those completing a curriculum approved by the IAMPE Board of Advisors in the TSU undergraduate program.
3. One faculty member participation in the full seminar (MPM/MPE) at no cost. Two undergraduate students will also be allowed to attend the MPM portion of the program at no charge.
4. Provision of MPM program and MPE program at no cost, including updates, for use by TSU faculty as they deem appropriate.
5. Access to the IAMPE electronic studies library at no charge.
6. Formal recognition of TSU as an academic partner with the IAMPE, one of the most important port and maritime educational industry associations in North America. Use of the IAMPE logo on TSU web sites, social media, and printed material.
7. Connection to the local maritime industry through the IAMPE and educational partner, the Greater Houston Port Bureau.
8. Assistance for certified graduates in connecting with ports or terminals looking for qualified personnel.
9. Advertising and promotion of the TSU graduate program to seminar participants in the industry, connection on IAMPE web site, and the vehicle for interested members who would like to enroll in the undergraduate and graduate programs at TSU.
10. All attendees will receive a free membership to the IAMPE.

By establishing such a partnership with IAMPE, TSU maritime students will have a great opportunity to be granted with these certifications at no additional cost. It will make our graduates more employable and will make our maritime programs more attractive to the students and more visible in the field.

CHAPTER 4: STUDENT DEVELOPMENT

The third and most important objective of the TSU DHS SLA program is to increase the number and quality of students who graduate in a STEM discipline within Minority Serving Institutions (MSI). To achieve this objective, our team has been focused on two aspects: **attracting more high school students to TSU maritime transportation program** and **supporting current students especially DHS SLA-supported students**. In this chapter, the efforts put into these two aspects are introduced.

4.1 Recruiting Activities

Recruiting more students into the HS-STEM field is a key aspect of this program. To attract more students to the Maritime Program at TSU, the Department of Transportation Studies frequently visits local high schools during their college day and other occasions. In addition, the Department of Transportation Studies at TSU hosted the annual Summer Maritime Academy for high schools in Houston Area. Also, in cooperation with Elkins High School Engineering Academy, the TSU Department of Transportation Studies has hosted the summer internship program.

4.1.1 Summer Maritime Academy

Summer Maritime Academy (SMA) is a five-day non-residential program designed to introduce high school students to the maritime industry. The program also introduces students to the Maritime Transportation Management and Security degree program and scholarship opportunities at TSU. During the week, the topics of logistics, security, and the environment (vehicle emissions) were covered and students enjoyed field trips to the Port of Houston Authority and U.S. Coast Guard facility. U.S. Customs and Border Protection Agency officials also visited with students and demonstrated cargo screening techniques to detect contraband items in cargo. Students also learned transferable skills through sessions on Leadership, Dealing with Change, and Effective Communication Strategies.

SMA is an annual event and has been welcomed by high school students. However, due to the outbreak of COVID-19, 2020 SMA was canceled. TSU transportation studies will continue to host SMA in the future when conditions permit. The following figures show student activities during SMA.

Figure 4-1: Student Activities during SMA 2016

Figure 4-2: Student Activities during SMA 2017

Figure 4-3: Student Activities during SMA 2018

Figure 4-4: Student Activities during SMA 2019

4.1.2 Summer Internship Program with Elkin High School Engineering Academy

Since summer 2015, the Department of Transportation Studies at TSU started the Summer Internship Program with Elkins High School Engineering Academy. This program was designed to attract high school students to the Maritime Management and Security Program. This two-week internship program offers high school students the opportunity to work with professors and graduate students in our research labs, enabling them to participate in various research projects and learn about many of the tools and software programs that were used for transportation research purposes.

Figure 4-5: Summer Intern Students with Dr. Yi Qi, Graduate Student and Undergraduate Student

4.2 Maritime Program Events and Activities

The department of Transportation Studies and DHS SLA team at TSU continue to provide learning and networking opportunities to maritime undergraduate students by hosting numerous events and encouraging them to participate in various maritime security-related conferences and events.

4.2.1 Conferences Attended by Our Faculty Members and Students

- Petrochemical and Maritime Outlook Conference
- International Trade Center Monthly Industry Luncheon
- Break-bulk Education Conference
- Transportation Research Board (TRB) Annual Conference
- (TAG) Congressional Synergy Series – Energy & Transportation
- Maritime & Logistics Youth Expo
- Port of Future Conference

The following are photos taken during these conferences.

Figure 4-6: TSU Maritime Students and Faculty Members at Break-bulk Education Conference

Figure 4-7: TSU Maritime Students and Faculty Members at TRB Annual Meetings

Figure 4-8: TSU Maritime Students and Faculty Members at Maritime & Logistics Youth Expo

4.2.2 Field Trip and Visit

- CSCMP Tour of Texas Terminals LP
- Port of Houston Authority Partners in Maritime Education Counselor's Boat Tour
- Visit to Gulf Stream Marine

The following are photos taken during these visits.

Figure 4-9: CSCMP Tour of Texas Terminals LP

Figure 4-10: Port of Houston Tour

Figure 4-11: Visit to Gulf Stream Marine

4.2.3 Other events

- Several U.S. Coast Guard officers from Sector Houston visited the Department of Transportation Studies, 10/21/2015

- J.B. Hunt's Visit to TSU Maritime Transportation Management and Security program, 02/04/2016
- Nigerian Delegation Visit to TSU, 05/04/2016
- Naval Opportunities Awareness Workshop, 05/11/2016

4.3 Degrees Awarded from 2010-2020

This part analyzed the degree awarded each year. Figure 4-12 is the total undergraduate level degrees awarded each year for the College of Science, Engineering, and Technology (COSET). It can be seen that, after DHS SLA program launched in TSU in 2014, the number of students who graduated kept increasing. Before 2014, the average number of degrees awarded per year is 151, while after 2015, the number of degrees awarded per year is 233.

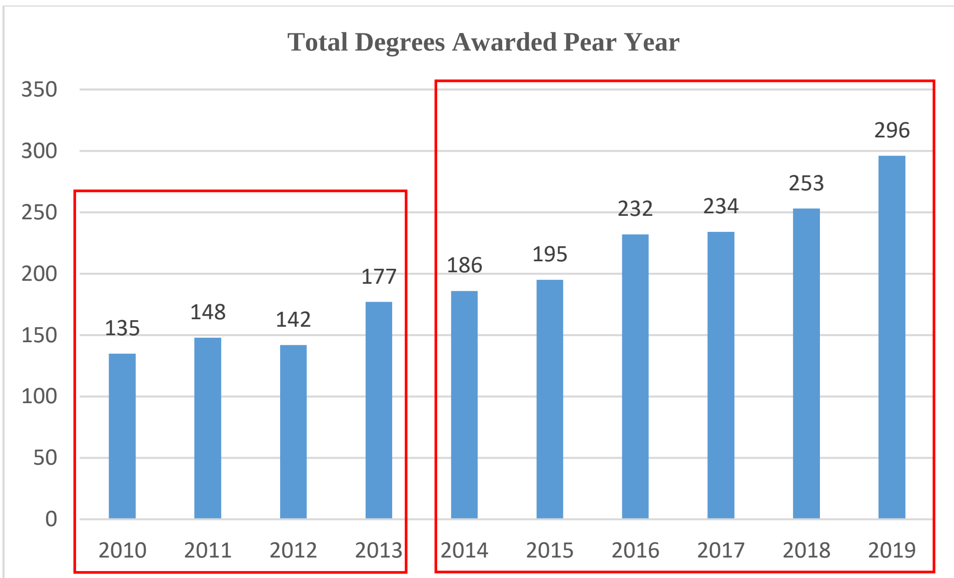

Figure 4-12: Total Degrees Awarded for All Majors in COSET

Some majors involved more in the TSU DHS SLA program, including Maritime Transportation Management and Security, Aviation Science Management, Civil Engineering Technology, Civil Engineering, Computer Science, Computer Engineering Technology, Electronics Engineering Technology, ECE, Mathematics and Chemistry. The degrees awarded for these majors were also continuously increased for most of the years. Figure 4-13 shows the number of degrees awarded per year for these majors. The average number of degrees awarded before and after our DHS program launched are 72 and 148.

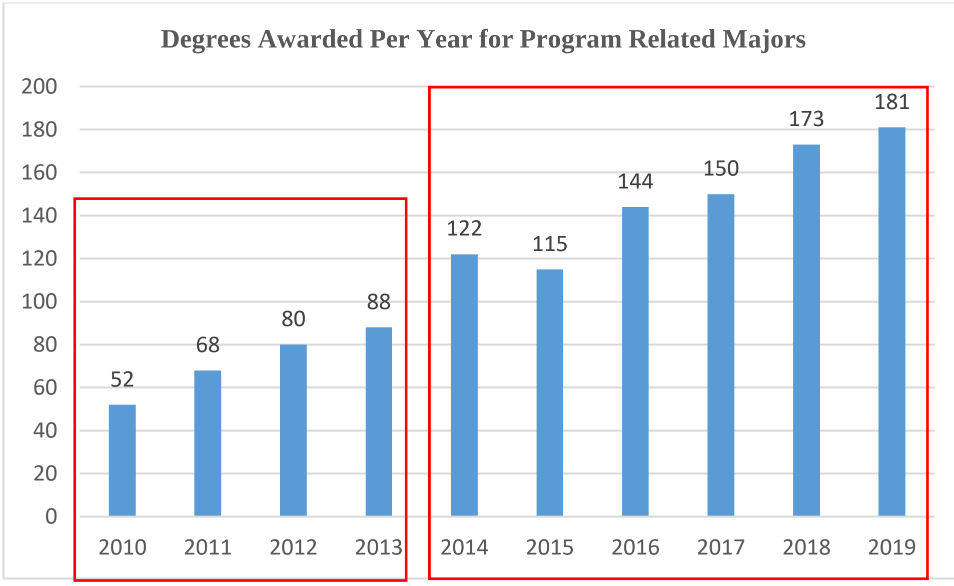

Figure 4-13: Degrees Awarded for Majors related to the TSU DHS SLA Program

Furthermore, Maritime Transportation Management and Security is the major program for the TSU DHS SLA Program. This program is developed by TSU by partnering with the Port of Houston Authority. The Bachelor of Science degree in Maritime Transportation Management and Security began in Fall 2010 and addresses three nationally recognized priorities: logistics/freight, security, and environment. Figure 4-14 shows the number of degrees awarded per year for these majors. TSU DHS SLA program also played an important role on increase the number of students graduated in Maritime Transportation Management and Security by providing research assistantships and scholarships. The average number of degrees awarded to students before and after 2014 are 7 and 11.

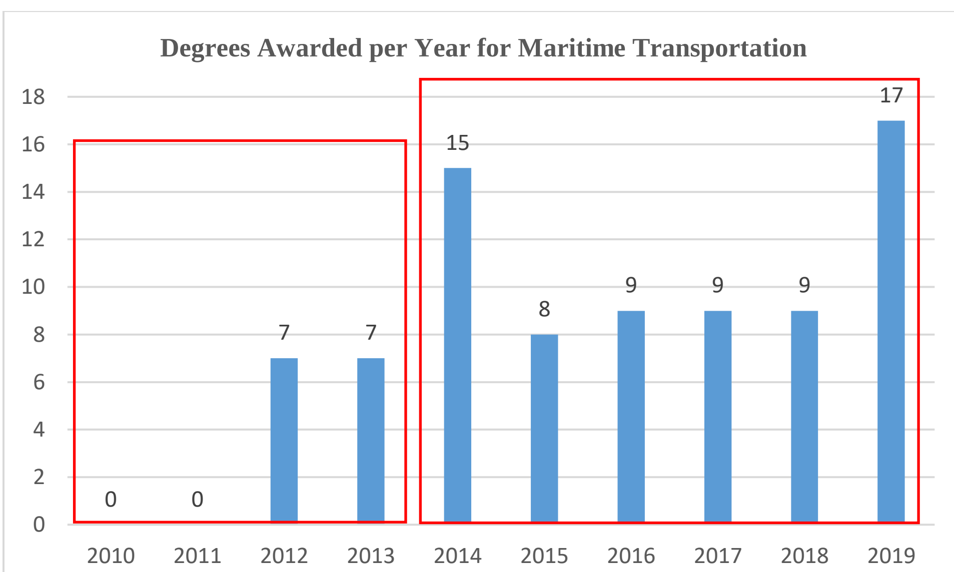

Figure 4-14: Degrees Awarded for Maritime Transportation

CHAPTER 5: COLLABORATIONS WITH DHS COES

5.1 Center for Risk and Economic Analysis of Terrorism Events (CREATE) at the University of Southern California (USC)

CREATE is the first COE we collaborate with. The collaboration between TSU DHS SLA with CREATE started in 2015. Dr. Milind Tambe, Professor of Computer Science & Industrial Systems Engineering at the University of Southern California, was recommended by CREATE and accepted to serve as a mentor for our research topic, "Secure and Efficient Maritime Data Storage and Retrieval." In addition, Dr. Tambe also hosted Dr. Miao Pan's visit to CREATE during June 18-28, 2015.

Dr. Tambe provided advice and technical support to the research team at TSU, and he also provided comments on critical tasks in the research program and reviewed the key documents or deliverables.

Figure 5-1: Dr. Miao Pan Visited CREATE in Summer 2015

5.2 Maritime Security Center of Excellence (MSC) at Stevens Institute of Technology (SIT)

In FY 2016, to expand the collaboration with other COEs, also recommended by CREATE, we started a new collaboration with the Maritime Security Center of Excellence (MSC) at Stevens Institute of Technology (SIT). The MSC conducts innovative research, develops new tools and technologies, and provides relevant maritime security-focused educational programs to enhance our nation's maritime domain awareness, the resiliency of our Marine Transportation System (MTS), and the technical skills and leadership capabilities of our current and prospective maritime security workforce. The mission and activities of MSC are more related to our maritime program.

The collaborations with MSC are summarized as:

- TSU supported MSC on winning an NSF funding award titled "Maritime Cybersecurity - Building Capacity in Critical Infrastructure Protection". In this project, TSU collaborates with Stevens Institute of Technology faculty on the development of maritime cybersecurity curricula to enhance the knowledge, technical skills, and research capabilities of our students and our partners in the maritime domain.
- Our supported undergraduate student Mr. Samuel Tefferra has participated in a highly collaborative eight-week intensive program hosted by Maritime Security Center. This program focused on critical issues in maritime domain awareness, emergency response, and maritime system resilience.
- Under the support of MSC at SIT, TSU has developed and submitted a new proposal titled "Environmental and Maritime Disaster Management (EMDM) of the Port of Houston" for the 2016 DHS Scientific Leadership Award Program. The proposed program is to address the DHS workforce shortage and diversity issues and broaden its current environmental and maritime training programs. Although this proposal has not been selected by DHS, this collaborative effort has lead to more collaborations between the different departments at TSU and the MSC.
- TSU collaborated with a DHS Center of Excellence, Maritime Security Center of Excellence (MSC) at Stevens Institute of Technology (SIT) on developing a maritime transportation system-focused cyber course titled "advanced maritime security." TSU is reviewing the pilot course materials developed by the MSC at SIT and providing our feedback to them to help to improve the curriculum.
- In summer 2020, TSU maritime student Trey Robertson was selected to participate Summer Research Institute (SRI) 2020 Virtual Program hosted by MSC.

Figure 5-2: TSU Maritime Student Trey Participating SRC Student Presentations

5.3 Borders, Trade, Immigration (BTI) Institute at the University of Houston (UH)

TSU started the collaboration with BIT in FY 2019 with the following activates:

- Dr. George Zouridakis, the Chair of the Research Committee of BTI, to give us a lecture titled "Homeland Security Challenges and the Role of the BTI Institute."

- The TSU DHS SLA team invited key personnel from BTI to visit TSU. In the meeting, the BTI team presented the status of the BTI Education Programs and TSU team explained in details the research activities and the education program we have developed and are implementing.
- Dr. Qi was invited by Dr. Abria Magee to the UH campus to attend a site demo for a BTI sponsored research project titled “the use of unmanned autonomous systems in maritime port security”.

Figure 5-3: Collaboration Activities with BTI

In the future, TSU DHS SLA team will continue to work closely with CEOs in terms of research and education.

CHAPTER 6: OTHER COLLABORATIONS

During the DHS SLA program period, our faculty members have actively collaborated with the faculty members/researchers from various universities on their research work. We also established collaborative relationships with different maritime organizations. In addition, our faculty members have attended various events for collaborating with other researchers or industry experts in the maritime security-related areas.

6.1 Collaboration with Different Universities on Research

Collaborate with Other Universities to Develop New Research Proposals

Faculty members of the TSU DHS SLA team also collaborated with other universities to develop new research proposals. For example, Dr. Yi Qi and Dr. Mehdi Azimi team up with professors from the University of Alabama, Clemson University, and Mississippi State University, University of Central Florida, Pennsylvania State University, and the University of Louisville to develop new proposals.

Collaborate with Other Universities on University Transportation Research Centers

The TSU has been collaborating with other four universities, the University of Texas at Austin (UT Austin), the University of Connecticut (UConn), and Washington State University (WSU) on a Tier 1 University Transportation Research Center named "Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE)" sponsored by U.S. Department of Transportation. For this center, we are conducting various research projects in the area of "Improving Mobility of People and Goods" by developing advanced technology, methods and models for multimodal transportation (including highway, air, rail, freight, public transit, bicycle, and pedestrian). We are also conducting various activities for educating and workforce development purposes. Dr. Yi Qi serves as CAMMSE's Associate Director at TSU.

Collaborate with University of Houston

TSU team has collaborated with Dr. Yupeng Zhang and Dr. Cheng Liang-Chieh, the faculty members at the University of Houston in the following aspects:

- Dr. Yupeng Zhang and Dr. Cheng, Liang-Chieh have been invited as the speakers for the TSU DHS SLA program Seminar and give a presentation on the topic of "The Future of National Security – Maritime Cybersecurity".
- Dr. Yupeng Zhang has developed a presentation on the "Cybersecurity Foundation and Awareness in Maritime" for the DHS SLA program.

6.2 Collaboration with Different Maritime Organizations

Collaborate with International Propeller Club Port of Houston to establish a student Chapter at TSU for Propeller Club

The International Propeller Club of the United States is an international business network dedicated to the promotion of the maritime industry, commerce and global trade. Professor Morgan received an invitation to start a student chapter at TSU for the International Propeller Club. Currently, they have a student Chapter at Texas M &A at Galveston.

In April 2018, Dr. Yi Qi, Professor Morgan and Ms. Williams met with Mr. Stuart Smith and Mr. William Wachel from the international Propeller Club port of Houston. The establish of TSU student chapter and collaboration with International Propeller Club will be a great benefit to our maritime students. They will have the opportunity to receive the scholarship from the club, and attend the club meetings and events, etc. It will help them in establishing and advancing their careers.

The Propeller Club of Houston is willing to help with the startup costs and sponsor all of the charter members for the first year and possibly the second year of the club to get it off the ground and running. Our maritime faculty, Capt. Morgan and Ms. Williams will serve as the advisors for this student organization.

<u>Collaborate with US Coast Guard on the College Student Pre-Commisioning Initiative (CSPI)</u>

On September 28, 2020, TSU signed a memorandum of agreement with the US Coast Guard at TSU. This memorandum will help to support the Coast Guard's College Student Pre-Commisioning Initiative (CSPI) and establish a partnership with TSU that will encourage officer recruitment opportunities.

6.3 Collaboration Events (Selected)

During the DHS SLA program period, our faculty members have actively collaborated with the faculty members/researchers from various universities or industry experts through attending conferences or workshops, especially those organized by DHS. Following is the list:

- DHS MSI Leverage Expertise in Academia for Placement in the DHS Enterprise Workshop, March 2016
- Visual Analytics for Command, Control and Interoperability Environments (VACCINE) Center's 2016 Visual Analytics MSI Faculty Training Workshop, May 2016
- The 5th Annual SCMI Spring Symposium, April 2016
- 4th Biennial TRB-CMTS Research and Development Conference, June 2016
- Southern Plains Transportation Center' workshop for Transportation Engineering Educators, July 2016
- Workshop on Enhancing Resiliency of Maritime Ports hosted by Florida Atlantic University, December 2016
- Computational and Systems Neuroscience, Salt Lake City, February2017
- The Get SMART Impact Workshop organized by Southeast Maritime and Transportation Center (SMART), May 2017
- 2017 Visual Analytics MSI Faculty Training Workshop, June 2017
- SIAM annual meeting, Pittsburgh, July 2017
- HBCU Flood and Hurricane Meeting, August 2017

- Industry seminar hosted jointly by West Gulf Maritime Association (WGMA) and the Baltic International Maritime Council (BIMCO), August 2017
- 6th Annual Maritime Security East Conference, April 2018
- 5th Biennial TRB-CMTS Research and Development Conference, June 2018
- Mid-year Meeting of TRB Standing Committee, June 2018
- 2018 Providing Data Literacy for a STEAM Curriculum Workshop hosted by The Center for Accelerating Operational Efficiency (CAOE), June 2018
- Visit of the Delegation of Japan's Maritime Bureau, Ministry of Land, Infrastructure, Transport and Tourism, July 2018
- CAMMSE First Symposium, August 2018
- Annual Supply Chain Management Institute (SCMI) Supply Chain Forum, 2018
- Collaborate with International Propeller Club port of Houston to establish a student Chapter at TSU for Propeller Club, 2018
- CSCMP Tour of Stolthaven Terminals, May 2019
- Mid-Year Joint Meeting of the TRB Marine Group Standing Committees, June 2019
- 2019 Esri User Conference July 2019
- Webinar: "Strategic Planning for Inland Ports", September 24, 2019
- Development of Spatial Data Infrastructures (SDI) for Marine Data Management, October 29, 2019
- Transportation Research Board (TRB) Standing Committees meeting, January 2020

The following are some selected events that are related to DHS or Maritime security.

<u>DHS MSI Leverage Expertise in Academia for Placement in the DHS Enterprise Workshop</u>

On March 2016, Dr. Mehdi Azimi attended the one-day DHS MSI Leverage Expertise in Academia for Placement in the DHS Enterprise Workshop with his student Mr. Samuel Teferra. The workshop included more than 100 attendees, including MSI faculty and students from 16 Minority Serving Institutions (MSIs) affiliated with the DHS Centers of Excellence (COEs), DHS Component representatives and higher education association representatives. The workshop addressed a recommendation from the Homeland Security Academic Advisory Council (HSAAC) that DHS should promote COE technologies and research projects by encouraging and expanding the use of activities that showcase COEs' technologies and research projects. Dr. Azimi had a presentation on the progress on TSU SLA program and showcased the accomplishments. Also, Samuel had a poster presentation on the research project conducted by him and Dr. Azimi that has been developed through the support of S&T OUP.

Figure 6-1: Student Samuel Teferra at DHS Enterprise Workshop

<u>Visual Analytics for Command, Control and Interoperability Environments (VACCINE) Center's 2016 Visual Analytics MSI Faculty Training Workshop</u>

The VACCINE Center, a U.S. Department of Homeland Security Science and Technology Center of Excellence, hosted the 2016 MSI Visual Analytics Faculty Training Workshop at Florida International University in Miami, Florida on May 11 and 12, 2016. Dr. Yunjiao Wang from our program attended this two-day workshop.

This workshop focused on preparing Minority Serving Institutions (MSI) faculty to incorporate visual analytics courses into their programs. Learning topics and activities in this two-day workshop included: understanding the theory and foundation of visual analytics, integrating visual analytics into course curriculum, developing learning communities for interdisciplinary courses, hands-on instructor-supported tutorials on extracting various forms of big data, and a unique group-designed application learning assignment.

Figure 6-2: Dr. Yunjiao Wang (third from left) with Other Participants at Visual Analytics MSI Faculty Training Workshop

The 5th Annual SCMI Spring Symposium

In April 2016, Robert Morgan Jr., Visiting Professor in the Texas Southern University Transportation Studies Department and 209 attendees from 65 different organizations and Universities participated in the 5th Annual Supply Chain Management Institute (SCMI) Spring Symposium held at the University of San Diego in the Kroc Institute for Peace & Justice (KIPJ). Among all University representatives including Harvard and Stanford University, Professor Morgan was the only Instructor from a Historically Black University, providing Expert knowledge in the field of Supply Chain Management, Transportation and Logistics.

In addition to actively participating in the various workshops, Professor Morgan collaborated with Joel Sutherland, Managing Director of SCMI at University of San Diego School of Business Administration Center to share unique ideas and action in support of his research study on Risk Analysis and Resiliency work for TSU Department of Homeland Security (DHS) Scientific Leadership Award Grant. The master's degree in supply chain program at University of San Diego SCMI School of Business is ranked in 9th in the nation accordance to U. S. News. Throughout this Symposium, vital information from current logistics professionals were given. Professor Morgan plans to disseminate this information to his classes this current semester, giving his students recent relevant knowledge in the area of Supply Chain Management, Transportation and Logistics.

Figure 6-3: Professor Morgan (middle) with Joel Sutherland, Managing Director, SCMI (left), and symposium participant

Enhancing Resiliency of Maritime Ports Workshop

On December 2016, Dr. Qi attended a one-day workshop on Enhancing Resiliency of Maritime Ports hosted by Florida Atlantic University at Dania Beach, Florida. This Workshop is to develop in-depth knowledge and understanding of the issues in port resiliency and to acquire and share information on current and developing efforts in port resiliency and risk management studies. It invited a range of port and coastal community stakeholders and researchers Dr. Qi was invited as a speaker for this workshop. In the workshop, Dr. Qi introduced the DHS SLA program at TSU and presented the research work that TSU team has been conducting on the topic of "Non-Intrusive Inspection (NII) Technologies for Inspection of Cargo at Ports of Entry". In this workshop, Dr. Qi also met Dr. Manhar Dhanak and Dr. Alka Sapat at Florida Atlantic University. They exchanged their research ideas and discussed the potential collaborations in the future. In July 2017, Dr. Qi provided assistance to Dr. Alka Sapat on conducting a survey to the executives at Port of Houston for a research project on port resiliency.

Figure 6-4: Dr. Yi Qi Presented at the Workshop on Enhancing Resiliency of Maritime Ports

<u>HBCU Flood and Hurricane Meeting</u>

During August 3-4, 2017, Dr. Qi attended the HBCU Flood and Hurricane meeting convened by the DHS Coastal Resilience Center of Excellence. In this meeting, Dr. Qi met researchers in different HBCUs and discussed how to increase the ability of HBCUs to support vulnerable communities to mitigate and recover from disasters caused by floods or hurricanes. After this meeting, Dr. Qi also joined the "HBCU Flood and Hurricane Meeting Attendees Workgroup" to continue the discussions on this topic.

Figure 6-5: Dr. Qi Yi with All Participants at HBCU Flood and Hurricane Meeting

Get SMART Workshop

Dr. Azimi attended the Get SMART Impact Workshop organized by Southeast Maritime and Transportation Center (SMART) in May 2017. The SMART Center is a National Science Foundation (NSF) Advanced Technological Education (ATE) Center in the maritime and transportation industry. There are over 40 ATE Centers across the country focused on improving science, technology, engineering, and mathematic (STEM) education to meet the technician workforce needs of advanced technological industries in the U.S., and SMART is the only ATE Center solely focused on the maritime and transportation industry.

Get SMART was a three-day professional workshop in Galveston, designed on important and required core concepts and materials to develop/expand academic courses and pathways in order to enable students to enter the maritime and transportation industry. During the workshop, speakers from SMART institute and also Port of Galveston had presentations, and the attendees had the opportunity to visit Port of Galveston (boat tour), G&H Towing Company, Vehicle Distribution Center of Wallenius Wilhelmsen Logistics, Texas Maritime Academy at Texas A&M University Galveston Campus, Pier 77 Marine Service (recreational and commercial full-service shipyard), and U.S. Coast Guard Galveston station.

Figure 6-6: Dr. Mehdi Azimi at Get SMART Impact Workshop

2017 Visual Analytics MSI Faculty Training Workshop

Dr. Azimi attended the Visual Analytics MSI Faculty Training Workshop organized by the Visual Analytics for Command, Control, and Interoperability Environments Center (VACCINE) in June. Vaccine is the Department of Homeland Security's (DHS) Center of Excellence in Visual and Data Analytics. The workshop was a two-day event held by Prairie View A&M University in both Prairie View and Houston campuses.

During the workshop, the principles of Visual Analytics and incorporating user feedback and Machine Learning for human-in-the-loop Visual Analytics were introduced to the attendees followed by a hands-on tutorial with Tableau software. Furthermore, the presenters discussed course module development and they shared their course development experiences with attendees. A group discussion was subsequently held on general Visual Analytics lesson development.

Figure 6-7: Dr. Mehdi Azimi with All Participants at 2017 Visual Analytics MSI Faculty Training Workshop

2017 Cyber Security Seminar

Dr. Azimi attended an industry seminar hosted jointly by West Gulf Maritime Association (WGMA) and the Baltic International Maritime Council (BIMCO) in August. Globally recognized BIMCO is the world's largest international shipping association, with over 2,100 members in more than 120 countries. Their membership includes ship owners, operators, managers, brokers and agents.

The focus of the seminar was on Cyber Security in the Maritime Environment and it was held at U.S. Coast Guard Sector Houston-Galveston. The program had key presenters from BIMCO, U.S. Coast Guard, Federal Bureau of Investigation (FBI), American Bureau of Shipping (ABS), Hudson Analytix, HUB International, Innove Strategies, and Royston-Rayzor.

Figure 6-8: Dr. Mehdi Azimi at 2017 Cyber Security Seminar

5th Biennial TRB-CMTS Research and Development Conference, Jun 19-21, 2018

Dr. Azimi's graduate student, Akintola Aremu, was selected and received a travel award by the 5th Biennial Research and Development Conference. The conference had been organized by Transportation Research Board - Committee on Marine Transportation Systems (TRB-CMTS), and Dr. Azimi and Akintola attended it on June 19 to 21, 2018. CMTS is a Federal Cabinet-level, inter-departmental committee chaired by the Secretary of Transportation, with purpose of creating a partnership of Federal departments and agencies with responsibility for the Marine Transportation System. The name of this year conference was "Transforming the Marine Transportation System through Multimodal Freight Analytics" and covered different areas related to maritime. Anne Aylward, Director of the U.S. Department of Transportation - Volpe Center, opened the conference with her talk. Then, the conference was started in different sessions including Data Analytics - Maritime and Freight, Data Analytics - Inland Waterways, Data Analytics - Port Performance, Decision Support - Resilience, Decision Support - Managing Flows, Decision Support - Safety, Decision Support - Environmental, Big Data and Machine Learning - Maritime Applications. Also, three plenary sessions were held during the conference with the following topics:

Figure 6-9: Dr. Azimi's graduate student, Akintola Aremu Presented at 5th Biennial TRB-CMTS Research and Development Conference

- Perspectives Driving MTS Freight Analytics
- Reaching the Vision: Advancing Multimodal Freight Network Analytics - The Challenges and Opportunities
- The Value of Multimodal Freight Network Analytics – Making the Case through Scenarios

The keynote speakers of the second day of the conference was John Kingston, Head of Community Engagement, Blockchain in Transport Alliance (BiTA) & Executive Editor, Freightwaves. *Mr. Akintola Aremu also presented his research with the title of "Determining the Accuracy of Vessels' Estimated Time of Arrival (ETA) with Different Output Parameters", conducted under supervision of Dr. Azimi during the Student Honor Panel of the conference.*

<u>6th Annual Maritime Security East Conference</u>

Dr. Azimi attended the Maritime Security East Conference that was held from 2nd to 4th April 2018 at the Norfolk, VA. The conference was the 6th installment in the Maritime Security East program series and the 24th maritime security conference hosted by Homeland Security Outlook since 2011. The conference furthered the commitment to address the needs of governments, law enforcement, and critical infrastructure to counter the challenges of securing coastlines, inland waterways, ports and their critical infrastructure. On the first day of the conference, on-water vessel and pierside technologies were demonstrated to the attendees in the field. The conference started officially on April 3 and the Rear Admiral Scott A. Buschman, U.S. Coast Guard Deputy Commander of Atlantic Area kicked off the general session as the keynote speaker. On the third day, Kimberly Chatman, the Program Analyst of FEMA Grant Programs Directorate had a presentation on the Port Security Grant Program. Various maritime security related topics were presented during the conference, including:

- Maritime Security Issues: Cybersecurity; the National Maritime Security Advisory Committee and Facility Security Officer Training
- Detecting and Tracking the Small Dark Vessels
- Cyber Security Incident Response and Continuity of Operations Planning
- Cyber Threats to the Commercial Maritime Transportation System
- National Maritime Sensor Survey and Its Impact on Maritime Domain Awareness
- Enhancing Coastal and Border Security through High Performance Data Analysis
- Using Existing Technologies for Command, Control and Communications for Underway Assets and Shore Based Command Centers
- Drones Use and Regulations for Ports Security and Law Enforcement

The event also showcased products, technologies, and services that would support and enhance maritime security.

Figure 6-10: 6th Annual Maritime Security East Conference

<u>2018 Providing Data Literacy for a STEAM Curriculum Workshop</u>

The Center for Accelerating Operational Efficiency (CAOE), a U.S. Department of Homeland Security Science and Technology Center of Excellence led by Arizona State University, develops and applies advanced analytical tools and technologies to enhance planning, information sharing and real-time decision-making in homeland security operations. CAOE hosted the 2018 Providing Data Literacy for a STEAM Curriculum Workshop at Arizona State University on June 21 and 22, 2018. Dr. Azimi from our program attended this two-day workshop. The workshop focused on establishing data literacy in STEAM curriculum with the use of data analytic tools, and the development of course materials for teaching data analytic tools. Tutorials for two commonly used data analytic tools, Minitab and Tableau, were presented from both visual and numerical analytics perspective. The workshop only covered the use of these tools, but also a detailed discussion and experiences on incorporating analytic tools into curriculum. Participants in the workshop were Minority Serving Institution faculty with an interest in incorporating data literacy into their curriculum.

Figure 6-11. Dr. Azimi at 2018 Providing Data Literacy for a STEAM Curriculum Workshop

<u>Annual Supply Chain Management Institute (SCMI) Supply Chain Forum</u>

Professor Morgan attended the annual Supply Chain Management Institute (SCMI) Supply Chain Forum at the University of San Diego. At the meeting, he has consulted, examined, and explored issues on risk management and analysis with over 150 attendees and dozens of companies, including members from the DHS COE Maritime Security Center of Excellence (MSC) Stevens Institute of Technology.

Figure 6-12. Annual SCMI Supply Chain Forum at University of San Diego

<u>Mid-Year Joint Meeting of the TRB Marine Group Standing Committees 2019</u>

Mid-Year Joint Meeting of the TRB Marine Group Standing Committees (Ports and Channel (AW010), Inland Water Transportation (AW020), and Marine Environment (AW030)) was held in Gaveston, Texas, from June 12 to 14, 2019. Dr. Azimi, who is the member of two committees (AW010 and AW020), attended the event and meetings. The general meeting started in the morning of the first day with two plenary panels. The first panel was focused on digitalization in ports and supply chain; and the topic of the second session was "IMO 2020 and Future Outlook for Maritime." In the afternoon, the attendees took the tour of Texas A&M Galveston Campus and visited different maritime and marine related labs and facilities. Then, the joint meeting of the TRB Marine Group Committees was held.

The second day, the attendees visited the Port of Galveston and also the Bayport Container Terminal of the Port of Houston. They also took the M/V Sam Houston tour of the Houston Ship Channel. The attendees visited Shell Deer Park refinery on the third day of the event.

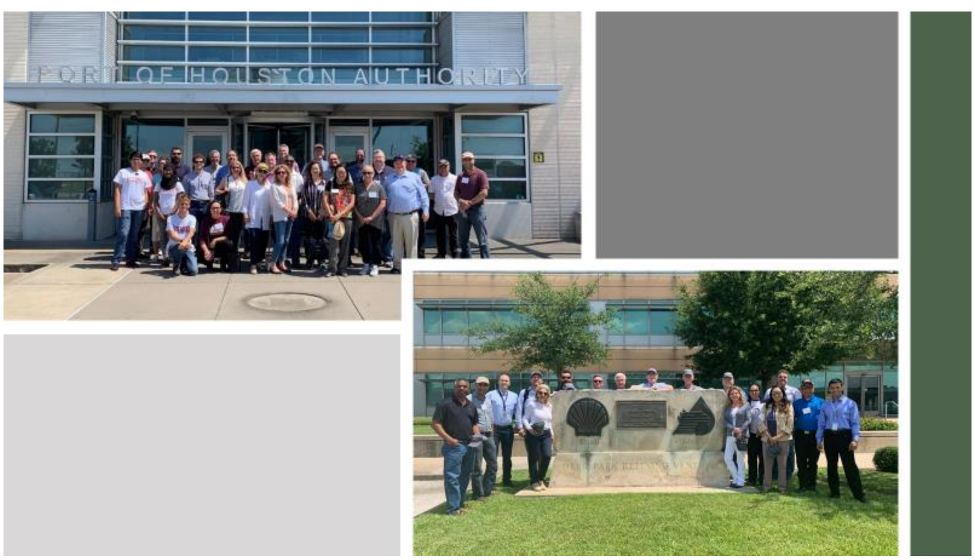

Figure 6-13: Dr. Azimi Attended the Tour of Shell Deer Park Refinery and Port of Houston

Webinar: "Strategic Planning for Inland Ports"

Dr. Azimi attended a webinar on port planning on September 24, 2019, hosted by the International Association of Maritime and Port Executives (IAMP) and Inland Rivers, Ports & Terminals Association (IRPT). The title of the webinar was "Strategic Planning for Inland Ports" and it covered different types of planning, the planning process, and step-by-step methodology for planning.

Development of Spatial Data Infrastructures (SDI) for Marine Data Management

Dr. Azimi attended a webinar on "Development of Spatial Data Infrastructures (SDI) for Marine Data Management" on October 29, 2019. The webinar was held by the US Committee on the Marine Transportation System (CMTS).

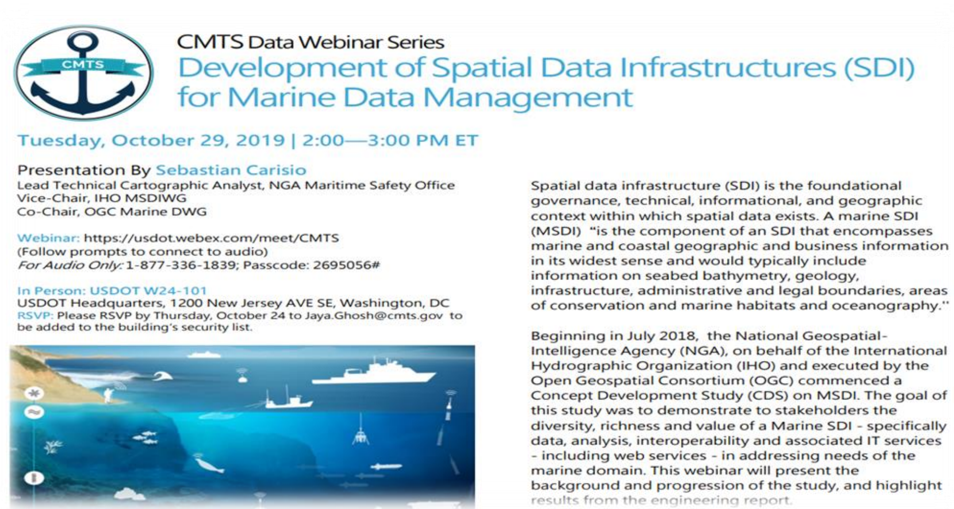

Figure 6-14: Dr. Azimi attended the webinar on Development of SDI for Marine Data Management

CHAPTER 7: PROGRAM ACHIEVEMENTS

Since 2014, program-supported faculty researchers and students have made lots of achievements in terms of their publications, presentations, and grant awards. Many high-quality papers were developed by our faculty researchers and students. They also attended various meetings and workshops to present their research. Moreover, new projects led by Dr. Yi Qi, Dr. Mehdi Azimi, and Dr. Yunjiao Wang were funded as a result of this DHS grant. This chapter summarizes all program achievements made during the past year.

7.1 Faculty Achievements

7.1.1 Publications

Journal papers accepted for publication

1. Qu, W., Sun, Q., **Zhao, Q**., Tao, T., **Qi, Y**. Statistical Analysis of Safety Performance of Displaced Left-Turn Intersections: Case Studies in San Marcos, Texas. Int. J. Environ. Res. Public Health. 2020, 17, 6446.
2. X. Yi, R. Guo and **Y. Qi**, Stabilization of Chaotic Systems with Both Uncertainty and Disturbance by the UDE-Based Control Method, in IEEE Access, vol. 8, pp. 62471-62477, 2020, doi: 10.1109/ACCESS.2020.2983674.
3. Qu,.W., T. Tao, **Q. Zhao**, Q. Sun, and **Y, Qi**, Two-Way Left Turn Lane or Raised Median? A Truck Safety Based Study, Journal of Safety Research, May 2020
4. Liu, Z., Guo, R., **Qi, Y**., and Jiang, C. Simultaneity of Synchronization and Antisynchronization in a Class of Chaotic Systems. Mathematical Problems in Engineering, 2020.
5. M. Golubitsky, Y. Zhao, **Y. Wang**, Z. Lu. The Symmetry of Generalized Rivalry Network Models Determines Patterns of Interocular Grouping in Four-Location Binocular Rivalry, J. Neurophysiology. Sept. 18, 2019 (doi:10.1151/jn.00438.2019)
6. A. Ben-Tal, **Y. Wang**, and M. C. Leite. The logic behind neural control of breathing pattern.Scientific Reports 9: 9078, 2019. (doi.org/10.1038/s41598-019-45011-7)
7. **Y. Wang**, Z. Kilpatrick and K. Josic. A hierarchical model of perceptual multistability involving interocular grouping. Journal of computational Neuroscience. 2020. (DOI: 10.1007/s10827-020-00743-8)
8. Yu Zhang, Vidhi Chandra, Erick Riquelme Sanchez, Prasanta Dutta, Pompeyo Quesada, Amanda Rakoski, Michelle Zoltan, Nivedita Arora, Seyda Baydogan, William Horne, Jared Burks, Hanwen Xu, S. Perwez Hussain, Huamin Wang, Sonal Gupta, Anirban Maitra, Jennifer Bailey, Seyed Javad Moghaddam, Sulagna Banerjee, **Ismet Sahin**, Pratip Bhattacharya, and Florencia McAllister, "Interleukin 17 induced- neutrophil extracellular traps mediate resistance to checkpoint blockade in pancreatic cancer" (Accepted on July 6, 2020 by) Journal of Experimental Medicine
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line search," Evolutionary Intelligence, Mar. 16, 2020 (DOI: https://doi.org/10.1007/s12065-020-00380-1)

10. De Jesus-Acosta, Ana and Sugar, Elizabeth A. and O'Dwyer, Peter J. and Ramanathan, Ramesh K. and Von Hoff, Daniel D. and Rasheed, Zeshaan and Zheng, Lei and Begum, Asma and Anders, Robert and Maitra, Anirban and McAllister, Florencia and Rajeshkumar, N. V. and Yabuuchi, Shinichi and de Wilde, Roeland F. and Batukbhai, Bhavina and **Sahin, Ismet** and Laheru, Daniel A., "Phase 2 study of vismodegib, a hedgehog inhibitor, combined with gemcitabine and nab-paclitaxel in patients with untreated metastatic pancreatic adenocarcinoma," British Journal of Cancer, vol. 122, no. 4, pp. 498—505, Feb. 18, 2020
11. Sun, X., X. Chen, **Y. Qi**, B. Mao, L. Yu and P. Tang. "Effects of advanced traffic signal status warning systems on vehicle emission reductions at signalized intersections", Journal of the Air & Waste Management Association, Vol. 69, Issue 4, pp. 391-401, 2019.DOI:10.1080/10962247.2018.1506834
12. Qu, W., T. Tao, **Q. Zhao**, Q. Sun, and **Y. Qi**, "Two-Way Left Turn Lane or Raised Median? A Truck Safety–Based Study", accepted for presentation and publication in the proceedings of the 98th Transportation Research Board Annual Meeting, Washington, DC, Jan.13-17, 2019
13. Erick Riquelme, Yu Zhang, Liangliang Zhang, Maria Montiel, Michelle Zoltan, Wenli Dong, Pompeyo Quesada, **Ismet Sahin**, Vidhi Chandra, Anthony San Lucas, Paul Scheet, Hanwen Xu, Samir M. Hanash, Lei Feng, Jared K. Burks, Kim-Anh Do, Christine B. Peterson, Deborah Nejman, Ching-Wei D. Tzeng, Michael P. Kim, Cynthia L. Sears, Nadim Ajami, Joseph Petrosino, Laura D. Wood, Anirban Maitra, Ravid Straussman, Matthew Katz, James Robert White, Robert Jenq, Jennifer Wargo, and Florencia McAllister, "Tumor Microbiome Diversity and CompositionInfluence Pancreatic Cancer Outcomes," Cell, vol. 178, pp. 795–806, Aug. 8, 2019
14. Ben-Tal, A., **Wang, Y**., & Leite, M. C. A. The logic behind neural control of breathing pattern. Scientific Reports, 9(1), 9078. 2019. https://doi.org/10.1038/s41598-019-45011-7 (AB and YW are co-first authors).
15. M. Golubitsky, Y. Zhao, **Y. Wang** and Z. Lu. Predicting Percepts from the Symmetry of Generalized Rivalry Network Models. Journal of Neurophysiolo.2019
16. **Zhao, Q**., T. Goodman, **M. Azimi**, **Y. Qi**, "Roadway Related Truck Crash Risk Analysis: Case Studies in Texas", Transportation Research Record, August 29, 2018. https://doi.org/10.1177/0361198118794055
17. **Yi, Q**, Q. Sun, **Q. Zhao**, T. Tao and W. Qu, "Safety Performance of Displaced Left Turn Intersections Case Studies in San Marcos, Texas", accept for presentation in the 98th Transportation Research Board Annual Meeting, Washington, DC, Jan.13-17, 2019

18. **Azimi, M.**, A. M. Aremu and **Y. Qi**. Analysis of Predicted Vessel Arrival Time to Multimodal Container Terminals in Lieu of Operator-Input ETA: A Case Study of the Port of Houston. Accepted for presentation in the 98th Transportation Research Board Annual Meeting, Washington D.C., Jan.13-17, 2019.
19. **Y. Wang**, K. Chilakamarri, D. Kazakos and M.C. Leite (2017), Communication on Dynamics in network systems and their subnetworks, proceeding of the 2017 International Symposium on Nonlinear Theory and its App.
20. Zhang Y., Zoltan M., Riquelme E., Xu H., **Sahin I.**, Castro-Pando S., Montiel MF., Chang K., Jiang Z., Ling J., Gupta S., Horne W., Pruski M., Wang H., Sun SC., Lozano G., Chiao P., Maitra A., Leach SD., Kolls JK., Vilar E., Wang TC., Bailey JM., McAllister F., "Immune Cell Production of Interleukin 17 Induces Stem Cell Features of Pancreatic Intraepithelial Neoplasia Cells," Gastroenterology, vol. 155, no: 1, pp. 210-223, Mar 29 2018. DOI: 10.1053/j.gastro.2018.03.041
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22. **Qi, Y** and A. Guo, "Pedestrian Safety Under Permissive Left-Turn Signal Control", accepted for publication at International Journal of Transportation Science & Technology, 2017.
23. **Qi, Y.** and **Q. Zhao**, "Safety impacts of signalized lane merge control at highway work zones", Journal of Transportation Planning and Technology, Vol. 40, Issue 5, pp.577-591, 2017.
24. Kou, W., X. Chen, L. Yu, **Y. Qi**, and Y. Wang. "Urban Commuters' Valuation of Travel Time Reliability based on Stated Preference Survey: A Case Study of Beijing", Journal of Transportation Research Part A. Vol. 95: 372-380, 2017.
25. Wang, Y., X. Chen, L. Yu, and **Y. Qi.** "Calibration of the Platoon Dispersion Model by Considering the Impact of the Percentage of Buses at Signalized Intersections", In Transportation Research Record: Journal of Transportation Research Board, No. 2647, DOI 10.3141/2647-11, Transportation Research Board of the National Academies, Washington, DC, 2017.
26. Teng, H., A. Puli and **Y. Qi**, "Identification of Influencing Factors of Graffiti Occurrence at Nevada State Highway Bridges and Soundwalls", Journal of Infrastructure Systems, Vol. 23 Issue 4 , 2017.
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28. **Y. Wang**, B. Omidiran, F. Kigwe and K. Chilakamarri. Relations between the conditions of admitting cycles in Boolean and ODE network systems, Involve, Vol.10, No.5, 2017, 813–831. DOI 10.2140/involve.2017.10.813 (B. Omidiran and F. Kigwe were two undergraduates).

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30. A. Jacot-Guillarmod, **Y. Wang**, C. Pedroza, H. Ogmen, Z. Kilpatrick, K. Josić. Extending Levelt's Propositions to perceptual multistability involving interocular grouping. Cosyne Abstracts 2017, Salt Lake City USA.
31. A. Jacot-Guillarmod∗, **Y. Wang**∗, C. Pedroza, H. Ogmen, Z. Kilpatrick, K. Josić. Extending Levelt's Propositions to perceptual multistability involving interocular grouping. Vision Research. Volume 133, April 2017, Pages 37-46. (∗ are co-first authors)
32. **Qi, Y**., A. Padiath, **Q. Zhao** and L. Yu. "Development of Operating Mode ID Distributions for Different Types of Roadways under Different Congestion Levels for Vehicle Emission Assessment Using Moves", Journal of the Air & Waste Management Association, 2016. DOI:10.1080/10962247.2016.1194338
33. **Y. Wang**, B. Omidiran, F. Kigwe and K. Chilakamarri. Relations between the conditions of admitting cycles in Boolean and ODE network systems, Involve, 2016.

<u>Articles in Refereed Conference Proceedings</u>

1. **Qi, Y**., H. F. Jinna, **Q. Zhao**, M. Azimi, T. Tao. Countermeasures for Reducing Truck Congestion at Marine Terminals. Peer-reviewed and published in 99th Transportation Research Board Annual Meeting Compendium of Papers 2020.
2. **Qi, Y**., S. Liu, **Q. Zhao** and W. Qu and "development of a progression-based, signal-timing strategy for continuous flow intersections", accepted for presentation at the 98th Transportation Research Board Annual Meeting, Washington, DC, Jan.12-16, 2020, 2020.
3. Liu, P., and Y. Qi and "Analyzing Injury Severity of Large Truck Crashes Using a Partial Proportional Odds Model: A Case Study in Texas", accepted for presentation at the 98th Transportation Research Board Annual Meeting, Washington, DC, Jan.12-16, 2020, 2020.
4. **Qi, Y**., Y. Wang, X. Chen, and K. Cheu, "Methods of Dropping Auxiliary Lanes at Freeway Weaving Segments", accepted for presentation and publication in the proceedings of the 94th Annual Meeting of Transportation Research Board, Washington, DC, Jan 10-14, 2016, TRB 16-6748
5. **Qi, Y**., B. Mao, **Q. Zhao**, X. Sun and P. Tang, "Use of Advanced Traffic Signal Status Warning Systems for Improving Intersection Safety", accept for presentation and publication in the proceedings of the 94th Annual Meeting of Transportation Research Board, Washington, DC, Jan 10-14, 2016, TRB 16-6640
6. **Qi, Y**., Y. Wang, X. Chen and G. Liu, "Safety Impacts of Directional Median Openings at Downstream U-turn Locations", accept for presentation and publication in the proceedings of the 94th Annual Meeting of Transportation Research Board, Washington, DC, Jan 10-14, 2016, TRB 16-6761
7. Sun, X., X. Chen, **Qi, Y**., B. Mao and L. Yu, "Analyzing Effects of Different Advanced Traffic Signal Status Warning Systems on Vehicle Emission Reductions at Signalized Intersections", accept for presentation and publication in the proceedings of the 94th

Annual Meeting of Transportation Research Board, Washington, DC, Jan 10-14, 2016 , TRB 16-5294

8. Tang, P., **M. Azimi**, F. Qiao, L. Yu, “Impact of Eco-driving Advising Strategies on Vehicle Emissions for Vehicles Traveling within Intersection Vicinities”, accept for presentation and publication in the proceedings of the 94th Annual Meeting of Transportation Research Board, Washington, DC, Jan 10-14, 2016, TRB 16-2410

7.1.2 Seminar/Conference/Workshop Presentations

1. **Dr. Yi Qi** presented “Implementation of Innovative Intersection Designs in Texas” at Zhejiang Normal University, June 2018.
2. **Professor Morgan** presented Transportation, Logistics, and Security lectures at the Annual Channelview ISD Career Day
3. **Dr. Ismet Sahin** chaired a session named “Applications of Global Optimization” in the conference INFORMS 2017 and was also responsible for preparing this session and reviewing and organizing the attenders of this session.
4. Abayomi Ajofoyinbo and **Ismet Sahin,** “Electrical Power Grid Optimization using Semi-Markov Decision Process,” INFORMS 2017, Houston, TX, October 2017
5. Nuri Yilmazer and **Ismet Sahin**, “Accurate Beamforming by Using Population Based Optimization Method,” INFORMS 2017, Houston, TX, October 2017
6. **Dr. Yi Qi**, “Estimation of Design Lengths of Left-turn Lanes”, 2017 TRB
7. **Dr. Yi Qi**, “Non-Intrusive Inspection (NII) Technologies for Inspection of Cargo at Ports of Entry”, Workshop on Enhancing Resiliency of Maritime Ports, at Florida Atlantic University, December 2016.
8. **Dr. Mehdi Azimi,** “Dilemma Zone Driving Behavioral Analysis at Signalized Intersections under Foggy Weather Condition with In-Vehicle Advance Warning Message”, TRB, 2017
9. **Dr. Yi Qi,** “Autonomous Vehicles: Impacts and Challenges”, CICTP2017, Shanghai, China
10. **Dr. Ismet Sahin** and Nuri Yilmazer, “Frequency Domain Time Delay Estimation with Optimization Over Randomly Selected Lines,” GOC 2017, College Station, TX, March 2017
11. **Dr. Yi Qi** invited to give a presentation titled “Active Leaning Strategies for Transportation Courses at Texas Southern University” in a workshop for Transportation Engineering Educators sponsored by the Southern Plains Transportation Center.
12. **Dr. Yunjiao Wang**, invited to give a presentation at a session of “Differential Equation Modeling and Analysis for Brain and other complex bio-systems” in the 11th AIMS International Conference on Dynamical Systems, Differential Equations and Applications held at Orlando, Florida, July 1 - July 5, 2016. Talk title: Extending Levelt's Propositions to multistable Perceptual rivalry involving interocular grouping.
13. **Dr. Yunjiao Wang**, invited to give a presentation in Workshop 1: Dynamics in Networks with Special Properties held at Mathematical Biosciences institute, Ohio State University,

held from January 25, 2016 to January 29, 2016. Talk title: Extending Levelt's Propositions to multistable Perceptual rivalry involving interocular grouping.

14. **Capt. Robert Morgan**, speaker at Houston Community College Annual Maritime Logistics Education Conference, October 23, 2015
15. **Capt. Robert Morgan**, speaker for International Trade Center Seminar, September 23, 2015

7.1.3 Funded Projects

1. PI: **Dr. Yi Qi** and Co-PI: **Dr. Mehdi Azimi**, **Qun Zhao**, “Development of Guidelines for Implementation of Coutraflow Left-Turn Lanes at Signalized Intersections”, $ 54,052.01, U.S. Department of Transportation, University Transportation Center Program, Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE), 2019-present
2. PI: **Dr. Mehdi Azimi** and Co-PI: Dr. **Yi Qi**, “Bicycle Network Connectivity and Accessibility: A Study on the Effects of Bike Infrastructures on Bicycle Sharing System Demand”, $59,880, U.S. Department of Transportation, University Transportation Center Program, Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE), 2019-present
3. PI: **Dr. Mehdi Azimi** and Co-PI: Dr. **Yi Qi**, “Analysis of Intermodal Vessel-to-Rail Connectivity”, $59,430, U.S. Department of Transportation, University Transportation Center Program, Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE), 2019-present
4. PI at TSU: **Dr. Yunjiao Wang**, Co-PI at TSU: Daniel Vrinceanu, Leading Institution: Prairie View A&M, PI: Lei Huang. “Excellence in Research: Collaborative Research: Strengthen the Foundation of Big Data Analytics via Interdisciplinary Research among HBCUs”, $466,515, NSF (CNS-1831980). 10/1/2018 - 9/30/2021
5. PI: **Dr. Yunjiao Wang**, “Research Initiation Award: Studying the Dynamics of Network Systems by Using Ordinary Differential Equations and Boolean Frameworks”, $283,194, NSF. 5/1/2018 - 4/30/2021
6. PI: **Dr. Yunjiao Wang**, Partner in a 2019 University of South Florida Nexus Initiative (UNI) Award. TSU received US$11,600 for 1 year. 2019 – 2020
7. PI: **Dr. Yi Qi** and Co-PI: **Dr. Mehdi Azimi**, **Qun Zhao**, “A New Method for Estimating Truck Queue length at Marine Terminal Gates”, $ 52,401.76, U.S. Department of Transportation, University Transportation Center Program, Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE), 2019-present
8. PI: **Dr. Mehdi Azimi** and Co-PI: Dr. Yi Qi, “Analysis of Intermodal Vessel-to-Rail Connectivity”, $59,430.30, U.S. Department of Transportation, University Transportation Center Program, Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE), 2019-present

9. PI: **Dr. Mehdi Azimi** and Co-PI: **Dr. Yi Qi**, "Bicycle Network Connectivity and Accessibility: A Study on the Effects of Bike Infrastructures on Bicycle Sharing System Demand", $59,880.28, U.S. Department of Transportation, University Transportation Center Program, Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE), 2019-present
10. PI: **Dr. Yunjiao Wang**, NSF - NSF - NSF - Excellence in Research: Collaborative Research: Strengthen the Foundation of Big Data Analytics via Interdisciplinary Research among HBCUs ($466,515) 10/1/2018 – 9/30/2021, PI at TSU Yunjiao Wang; co-PI at TSU: Daniel Vrinceanu, Leading Institution: Prairie View A&M, PI: Lei Huang)
11. PI: **Dr. Yi Qi** and Co-PI: **Dr. Mehdi Azimi**, **Qun Zhao,** "Development of Guidelines for Implementation of Contraflow Left-turn Lanes at Signalized Intersections", $53,882.68, U.S. Department of Transportation, University Transportation Center Program, Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE), 2018-present
12. PI: **Dr. Yi Qi** and Co-PI: **Dr. Mehdi Azimi**, **Qun Zhao**, "Signal Timing Strategy for Displaced Left Turn Intersections", $54,497.93, U.S. Department of Transportation, University Transportation Center Program, Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE), 2018-present
13. PI: **Dr. Mehdi Azimi**, Co-PI: **Dr. Yi Qi**, "Impacts of Bicycling Corridor Improvements on User's Behaviors in Large Cities", $59,939.73, U.S. Department of Transportation, University Transportation Center Program, Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE), 2018-present
14. PI: Dr. Saydam and Co-PI: **Dr. Yunjiao Wang**, "NSF – Conference: Invitation to Mathematics", $ 17,312, 8/1/2018 – 7/31/2019
15. PI: **Dr. Yunjiao Wang**, NSF - Research Initiation Award: "Studying the Dynamics of Network Systems by Using Ordinary Differential Equations and Boolean Frameworks ($283,194). 5/1/2018 – 4/30/2021
16. PI: **Dr. Yi Qi** and Co-PI: **Dr. Mehdi Azimi, Qun Zhao**, "Determination of Freeway Acceleration Lane Length for Smooth and Safe Truck Merging", $57,642.31, CAMMSE Research Project
17. PI: Dr. **Yi Qi** and Co-PI: **Dr. Mehdi Azimi, Qun Zhao**, "Innovative countermeasures for reducing the truck waiting time at marine terminals", $57,709.01, CAMMSE Research Project
18. PI: **Dr. Mehdi Azimi** and Co-PI: **Dr. Yi Qi, Qun Zhao**, "Investigating the impact of different attributes on bicycling mode share as a multimodal connectivity strategy in large cities: A case study in Houston", $54,824.81, CAMMSE Research Project
19. PI: **Dr. Yi Qi** and Co-PI: **Dr. Mehdi Azimi**, Development of Systemic Large Truck Safety Analysis, (Texas Department of Transportation research project 0-6911, $118,036, 2016-2018)

20. PI: **Dr. Mehdi Azimi** and Co-PI: **Dr. Yi Qi**, Identify Project Criteria for ITS Deployment in Work Zone (Texas Department of Transportation research project 0-6915, $108,667, 2016-2018)

7.2 Student Achievements

The program supported students all made great progress on there have won various awards.

7.2.1 Student Highlight

Mr. Reese D. Selman, a former undergraduate student in the Maritime Management Transportation and Security program at Texas Southern University, has been supported by the Department of Homeland Security Scientific Leadership Award (DHS SLA) Grant awarded to Texas Southern University in September 2014. He has been working as an undergraduate research assistant on a project titled "Maritime Risk Assessment and Management" for this program.

Reese Selman received his bachelor's degree with Magna Cum Laude honors in Science in May 2016. Currently, he is a Student Attorney at Lone Star Legal Aid . 2nd year Juris Doctor Candidate in the Thurgood Marshal School of Law. When asked how the program helped him, he indicated that this program encouraged him to continue towards his ultimate goal of becoming a top maritime attorney. By participating in this program, he built his confidence to zealously peruse his goals beyond undergrad while learning self-discipline through the requirements and the work he completed for the program.

Reese is a pronounced example of how The Department of Homeland Security Award scholarship has helped our students in more ways than one.

Miss. Guillermina Sweeny is a DHS supported undergraduate student studying Maritime Transportation Management and Security at Texas Southern University. Miss Sweeny represented TSU at The International Organization of Black Security Executives (IOBSE) conference in Boca, Raton Florida from April 15th to April 19, 2019. It is the leading organization for minority security professionals. This was an all-expense-paid trip.

This year's conference included presentations by top security professionals from major companies such as Walmart, Microsoft, Johnson Controls, and other major companies. Professional headshots were taken and resumes were critiqued by top professionals. IOBSE gave its interns the opportunity to interview with companies such as Walmart, Ross, and other great companies. IOBSE also gave students extra perks such as gift cards worth up to a hundred dollars for winning challenges and gave other participating students scholarships for submitting an essay. Miss Sweeny won a 1500-dollar scholarship towards her tuition in the fall!

Figure 7-2: Ms. Sweeny at IOBSE Conference

7.2.2 Student Awards

The program supported students have performed very well in their study and research, and received various awards.

FY2016

- Tyrie Goodman, Dwight D. Eisenhower Transportation Fellowship from FHWA, Jan 2016
- Tyrie Goodman, College of Science, Engineering and Technology (COSET) Scholarship, 2016
- Cherie Brown, Department of Homeland Security Scholarship for Maritime Students, 2015-2016
- Cherie Brown, Honors award for academic achievement in Fall and Spring 2016 semesters,
- Cherie Brown, Texas Southern University Academic Scholarship, 2016
- Cherie Brown, Outstanding Undergraduate Achievement Award for Transportation Department, 2016
- Reese Selman, Department of Homeland Security Scholarship for Maritime Students, 2015-2016
- Reese Selman - International Transportation Management Association Scholarship, 2015
- David Utaegbulam, COSET Faculty and Staff Scholarship, Spring 2016

FY2017

- Tyrie Goodman, Dwight D. Eisenhower Transportation Fellowship from FHWA, Jan 2017
- Tyrie Goodman, College of Science, Engineering and Technology (COSET) Scholarship, 2017
- Tyrie Goodman, College of Science, Engineering and Technology (COSET) Outstanding Student Ambassador, 2017
- McKenzie Jones, College of Science, Engineering and Technology (COSET) Dean's List Honoree, 2017
- McKenzie Jones, Housing Department Honors scholar, 2017
- Taylor Webber, College of Science, Engineering and Technology (COSET) Honoree, 2017
- Ester Martinez-Belmares, College of Science, Engineering and Technology (COSET) Outstanding Student Ambassador, 2017
- LaTerrian Perkins, Ronald B. Thorton Scholarship by TSU Ocean of Soul Alumni Association
- LaTerrian Perkins, Dwight D. Eisenhower Transportation Fellowship from FHWA, Jan 2017
- LaTerrian Perkins, College of Science, Engineering and Technology (COSET) Dean's List Honoree, 2017
- David Utae, TSU President List Award, 2017
- David Utae, Western Area Links Endowed Scholarship, 2017

FY2018

- Tyrie Goodman won Fall 2017 Outstanding Thesis Award Winner
- TSU Dean's List Honoree: Grice Faith, Romero Alex, Jones McKenzie, Perkins Laterrian, Utaebbulam David, Padron Alejandra, Roberson Malikiya, Fadeyi Adedayo
- TSU Honor Roll: Grice Faith, Romero Alex, Jones McKenzie, Perkins Laterrian, Utaebbulam David, Padron Alejandra, Roberson Malikiya, Fadeyi Adedayo, Cervantes Yovanni, Sweeny Guillermina, Bubanje Ntwari

FY2019

- Miss Sweeny represented TSU at The International Organization of Black Security Executives (IOBSE) conference in Boca, Raton Florida from April 15th to April 19, 2019. It is the leading organization for minority security professionals. This was an all-expense paid trip.
- Dwight Eisenhower Fellowship: Chrystopher Terry, April Barefield
- Western Area Links Endowed Scholarship: David Utaegbulam
- Port of Houston Scholarship: Guillermina Sweeny
- TMCF Lowe's Scholarship: Adedayo Fadeyi
- GUS Academic Scholarship: Adedayo Fadeyi

- IOBSE Scholarship: Guillermina Sweeny
- TSU President's List Honoree: Alejandra Padron, Alex Romero, David Utaegbulam, Faith Grice, Jose Alvarado, McKenzie Jones, Faith Grice, Teneika Dancy
- TSU Dean's List Honoree: Alejandra Padron, Malikiya Roberson, Yovanni Cervantes, Dionne Lindsay, Guillermina Sweeny
- TSU Honor Roll: Ashley Hicks, Alejandra Padron, April Barefield
- TSU Housing Department Honors Scholar: McKenzie Jones, Teneika Dancy
- TSU 4.0 GPA Honoree: Alberto Zapeda, Jose Alvarado, Faith Grice
- TSU Outstanding Undergraduate Student: Faith Grice
- TSU COSET Scholarship: April Barefield, Dionne Lindsay, Guillermina Sweeny
- TSU's General Scholarship: Guillermina Sweeny

<u>FY2020</u>

- TSU President's List Honoree: Marco Collazo
- TSU Dean's List Honoree: Teidra Darett
- TSU Honor Roll: Marco Collazo
- TSU 4.0 GPA Honoree: Sharda Sonnier
- TSU COSET Scholarship: Igor Vouffo

7.2.3 Student Placement

The following table shows the student placement after graduation. Some students continued their studies at a higher level, while some other students found jobs. However, due to the current COVID-19 pandemic, one student is unemployed and we have lost contact with three students.

Table 7-1: Current Affiliations of DHS Supported Students

Last Name	First Name	Advisor	Current Affiliation
Barefield	April	Morgan, Robert	Unemployed due to COVID-19
Brooks	Hunter	Azimi, Mehdi	TSU Student-Enrolled Fall 2020
Bubanje	Ntwari	Williams, Ursala	TSU Student-Enrolled Fall 2020
Cervantes	Yovanni	Williams, Ursala	St. Vincent De-Paul Catholic School - Aftercare Program
Collazo	Marco	Sahin, Ishmet	Harris County Engineering Department.
Dancy	Teneika	Qi, Yi	TSU Student-Enrolled Fall 2020
Darrett	Teidra	Morgan, Robert	TSU Student-Enrolled Fall 2020
Fadeyi	Adedayo	Sahin, Ismet	Associate RF Capacity Engineer at U.S. Cellular
Goodman	Tyrie	Qi, Yi	Transportation Manager at BNSF Railway
Grice	Faith	Wang, Yunjiao	Reynolds & Reynolds - Software Development Company
Griffin	Grionde	Wang, Yunjiao	TSU Student-Enrolled Fall 2020
Guess	Najae	Williams, Ursala	TSU Student-Enrolled Fall 2020
Harper	Micah	Azimi, Mehdi	Naval Flight Officer
Hicks	Ashley	Williams, Ursala	Mediterranean Shipping Company - Export Documentation
Jones	McKenzie	Robert, Morgan	National Highway Traffic Safety Administration NHTSA - Region 6

Kashani	Nazreen	Pan, Miao	TSU-Student
King	Ta'Bria	Williams, Ursala	TSU Student-Enrolled Fall 2020
Law	Kenneth	Williams, Ursala	Motor Vehicle Operator at the Dept. of Veterans Affairs
Lindsay	Dionne	Qi, Yi	will enroll next semester for Graduate Program
Martinez-Belmares	Ester	Azimi, Mehdi	Chervon - IT
Nealey	Charmaine	Williams, Ursala	HEB- Assistant Manager
Padron	Alejandra	Morgan, Robert	Export Customer service at Leschaco, Inc.
Perkins	LaTerrian	Didikiri, Rita	Will enrolled in Spring 2021
Rice	Jaide	Wang, Yunjiao	Teacher at Worthing Highschool; will enroll in TSU for the Spring semester for Graduate Program
Roberson	Malikiya	Azimi, Mehdi	Stolt Nielsen - Operations Department
Romero	Alex	Sahin, Ismet	Threat Hunting Analyst At Freeporting (Cyber Security)
Selman	Reese D.	Azimi, Mehdi	Student Attorney at Lone Star Legal Aid
Sonnier	Sharda	Morgan, Robert	TSU Student-Enrolled Fall 2020
Sweeny	Guillermina	Qi, Yi	Logistics Analyst at Project One Logistics
Teferra	Samuel	Pan, Miao	Epicor Developer at Integrated Corrosion Companies
Terry	Chrystopher	Azimi, Mehdi	United Airline - Revenue Management Department
Utaebbulam	David	Wang, Yunjiao	University of Texas Health Science Center at Houston
Vouffo	Igor	Wang, Yunjiao	TSU Student-Enrolled Fall 2020
Webber	Taylor	Beverly	Teacher at Garcia Middle School, and will enrolled in Master Program in the spring
Zepeda	Alberto	Wang, Yunjiao	Engineering Intern
Alvarado	Jose	Azimi, Mehdi	Unknow
Brown	Cherie	Robert, Morgan	Unknow
Davis	Jnae	Wang, Yunjiao	Unknow

APPENDIX I TECHNICAL REPORT

MARITIME RISK ASSESSMENT, MANAGEMENT AND RESILIENCY ANALYSIS

Final Report

By Robert Morgan

September 2020

Introduction

Problem Statement

Despite mandates by the International Maritime Organization (IMO) and the U.S. Coast Guard to perform regular risk assessments at ports, onboard ships, and at the office, to verify how incidents, accidents, injuries, or near misses are caused, companies are frequently reluctant or unable to identify potential risks, thus imposing a threat to their own systemic integrity. This project examined the industry's practices and the identification of systemic failures, with the purpose of significantly improving corporate risk management and risk-assessment practices. It established a systemic platform for the maritime industry by modeling and analyzing risk assessment and management. It developed and validated the industry's regulatory requirements and standards by employing established, measurable, and demonstrable measures that will improve the prevention and vulnerability reduction measurements in the shipping industry. The results of this research project enhance the efficiency and functionality of the safeguard systems of the present maritime infrastructure.

Objectives

The objective of this study is to investigate the risk involved in Maritime Transportation and the significance of a system that ensures the safety and managing risk successfully. Because of the physical properties of water conferring buoyancy and limited friction, maritime transportation is the most effective mode to move large quantities of cargo over long distances. Main maritime routes are composed of oceans, coasts, seas, lakes, rivers, and channels. The terrorist attacks of September 11, 2001 in New York and Washington tragically illustrated the vulnerability of open economics to acts of terrorism. The strategies for U.S. Government shifted from mostly reactive attempts to a decidedly preventive and systematic approach. Due to potential threats, consequences, and vulnerability assessments, the maritime transportation industry, both on the water and ashore has risk management and security as top priorities. In essence, risk management is an analysis of the security risks, assessing and managing the risk, and the identification of measures to counter those threats. There is a process for identifying hazards and assessing these risks. A valuable base to this study will include security and safety decisions made by regulatory agencies, management and operations. The approaches made for this study will consist of research, data analysis, and literature review. The outcome of this project will provide the knowledge required to develop a new course on maritime risk assessment and resiliency analysis and update existing Maritime Transportation and Security courses.

Research Goal

The goal of this research is to evaluate, synthesize, and identify relevant research relating to security, maritime risk assessment, and risk management, and resiliency analysis. The information including current policies and procedures governance the research topic will be used to develop a new course for both traditional and online module methods. In addition to the new courses, the same information will be used to improve the following existing maritime security courses:

- MTMS 341 – Maritime Security Management

- MTMS 342 – Maritime Security Technology
- MTMS 424 – Containerization and Modern Cargo Storage
- MTMS 443 – Maritime Transportation Security

To achieve the goal and objective of this study, the proposed work plan consists of a total of 5 tasks over the period of the project.

Task 1: Literature search

Task 2: Literature review, analyze and synthesize the reviewed literatures

Task 3: Synthesize the methods and measurements for maritime risk assessment and management

Task 4: Synthesize the methods and measurements for maritime resiliency analysis

Task 5: Document research findings and provide recommendations

The research team will communicate regularly with the Project Mentor on the progress of the project. Comments and suggestions from Project Mentor will be properly addressed and incorporated into the ongoing research efforts.

Literature Search

To achieve the research goals, TSU research team led by Professor Morgan conducted qualitative research on the following keywords:

- Risk Management
- Risk Assessment
- Maritime Security
- Port Security
- ISPS Code
- Security-Related Agencies (i.e. DHS, USCG, CBP, IMO, MARAD, etc.)
- Cybersecurity
- Human Element

Our undergraduate assistants have conducted literature reviews on scholarly articles, including published government and non-government documents. The results of their work have led to a completed research report for a summer undergraduate research program sponsored by the College of Sciences, Engineering & Technology (COSET) at TSU, and a poster presentation for the same program.

In addition to the extensive research, collaborations with various security agencies (i.e., Department of Homeland Security, U.S. Customs and Border Protection, U.S. Coast Guard, the Port of Houston Authority Health, Safety, Security & Emergency Department, and the Maritime Administration), current lessons based on best practices are in place for the following security initiatives:

- Identifying the various risk and methods of risk management associated with maritime trade
- Managing the exposure to risk in both international and domestic maritime transportation
- Evaluating the effects of risk on maritime and port security
- Evaluating the human elements of risk assessment and management
- Handling risk from the perspective of both importers and exporters
- Constructing strategies for handling any perceived or expected risk
- Vessel, terminal, and security plans including the International Ship and Port Facility Security (ISPS) Code, cyber-security
- Methods used in port resiliency planning

Professor Morgan also visited the following U.S. CBP Ports of entry service points:

- San Ysidro, CA Port of Entry
- Otay Mesa, CA Port of Entry
- Brownsville, TX Port of Entry
- El Paso, TX Port of Entry
- Hidalgo, TX Port of Entry
- Pharr, TX Port of Entry
- Progreso, TX Port of Entry
- Laredo, TX Port of Entry

Methods and Measurements for Maritime Risk Assessment and Management

Casavant (2014) noted in an article on Maritime Borders; the United States relies on the U.S. Department of Homeland Security (DHS) to prevent the illegal flow of people and goods across the U.S. air, land, and sea borders. DHS accomplishes this while expediting the safe flow of lawful travel and commerce; ensure security and resilience of global movement systems; disrupt and dismantle transactional organizations that engage in smuggling and trafficking across the U.S. border.

The U.S. Coast Guard (USCG) is an essential component of U.S. border enforcement and protection strategies (Casavant, 2014). Three of the USCG mission supports the service's role in protecting borders and enforcing U.S. sovereignty. State sovereignty and territorial integrity are fundamental concepts in international relations and understanding the risk assessment at international borders. Keating, Howard, and Arimoto (2014) article on border security tools emphasized that the USCG monitors more than 95,000 miles of coastline, along with hundreds of ports, the Intracoastal Waterway, western rivers, and the Great Lakes to protect the nation's waters, the people who use them, and the national from the waterborne threat.

The USCG Domestic Port Security Evaluation Division provides a suite of integrated tools to assess, analyze, and mitigate risk. Tools such as:

- Port Security Risk Assessment Tool (PS-RAT), which allowed the captain of the port to evaluate port vulnerabilities;

- Maritime Security Risk Analysis Model (MSRAM) risk analysis tool to assess the risk of terrorist attacks;
- Risk Management Workspace (RMW) to display and communicate risk information.

U.S. Customs and Border Protection (CBP) is the unified border agency within the Department of Homeland Security charged with the management, control, and protection of our nation's borders at and between official ports of entry. The CBP continued with its risk-based strategy utilizing the three pillars of information, integration, and rapid response to maintain a level of effective border control. CBP obtained power by identifying cross-border threats, using and maximizing partnerships with federal, state, and local agencies, and deploying a rapid response to mitigate these threats quickly and effectively.

Risk Management

According to Vaughan and Vaughan (2014), as cited in David (2018), organizations can manage risks by retaining the risk, transferring the risk, or taking a blended approach through maintaining some of the risks and moving others.

Risk-retention occurs when an organization believes it is more economical not to buy insurance. The author identified the following four reasons for risk retention:

- Substantial international traders self-insure
- International traders with little exposure due to small value shipments
- International traders with little exposure due to the low percentage of their business which is international
- Out of ignorance

Risk transfer occurs when the organization transfers all risk to an insurance company. The author identified the following three reasons for risk transfer:

- The firm has a lot of exposure due to high-value shipments
- The firm has relatively high exposure
- The firm has minimal experience in international trade and is uncomfortable with risks, or they are unable to assess their exposure accurately

Mixed approach occurs when the organization retains some risk and transfers the rest. the organization achieved a strategy in two different ways.

- The firm determines the amount of exposure it can risk and assumes it through a deductible
- The firm decides the types of risks it will take and those it will transfer to an insurance company

Risk management consists of a series of steps that should be followed to reduce the consequences of disruptions. The steps include Risk Identification, Risk Assessment, Risk

Management Strategy Creation, and Risk Review and Monitoring (Coyle, Novack, & Gibson, 2016).

- Risk Identification: Step 1 involves the identification of the potential threats and disruptions to which the organization is susceptible. Structural and procedural changes may be required to execute the strategy.
- Risk Assessment - Step 2 focuses on the evaluation and prioritization of the risks. The more vulnerable the organization's transportation process is to a potential risk, the more attention it should receive. The objective of risk assessment is to evaluate the risks identified during Step 1 to determine how serious each risk is to the organization.
- Risk Management Strategy Creation - Step 3 requires the organization to develop proactive risk management and mitigation strategies. The goal is to lower the probability of risk occurrence or minimize the negative impact if the risk occurs. Organizations can assess the risk through one of four means: avoidance, reduction, transfer, or retention.
- Risk Review and Monitoring - Step 4 promotes continuity, vigilance, and process improvement. Ongoing testing of strategies, evaluation of their success, and scanning for new risks are needed to achieve maximum protection.

Transportation Risk Management

Coyle et al. (2016) described six different categories of transportation risk. The primary groups include:

- Product loss - any action or negligence that leads to product not reaching the intended buyer.
- Product damage is any potential peril that arises every time someone handles a shipment. The damaged product loses much, if not all, of its value.
- Product contamination is any spoilage, tampering, or exposure problem that leads to the corruption of the product and loss of value.
- Delivery delay - any failure to meet transit time and delivery deadline commitments constitute a delay.
- Supply chain interruption is a major problem that brings the transportation operation to a complete and prolonged stoppage.
- A security breach is a failure to adequately protect in-transit freight from potential security problems that threaten citizens and nations.

Transportation risk examples for each category as discussed throughout the chapter and are summarized in the following table:

Table 9-1 Transportation Risk Reduction Strategies

RISK CATEGORY	SPECIFIC RISKS	REDUCTION STRATEGIES	ANTICIPATED OUTCOMES
Product Loss	Theft and pilferage Piracy and hijacking Cargo jettison	Use generic packaging & descriptions Avoid lawless hot spots Strategic routing	Mitigate risk of financial loss, reduce customer delivery delays, and avoid replacement shipment expenses.
Product Damage	Operator accident Poor freight handling methods Improper equipment loading	Use protective packaging Establish training programs Monitor carrier performance	Enhance freight safety, reduce freight claims administration, and profit margin protection.
Product Contamination	Temperature control failure Product tampering Exposure to hazardous materials	Leverage pervasive automation Secure freight / lock containers Isolate dangerous freight	Safeguard brand equity, decrease potential for product liability lawsuits, and trim product recalls and inventory replacement costs.
Delivery Delay	Congestion Poor weather Equipment malfunction	Use event management software Employ dynamic re-routing tools Perform preventative maintenance	Proactive response to problems resulting in less wait time, greater delivery reliability, and improved customer satisfaction
Supply Chain Interruption	Capacity shortage Carrier bankruptcy Labor disruptions and strikes	Contract with quality carriers Monitor carrier finances Establish alternate carriers & ports	Avoid major disruptions of product flows that can impact supply chain productivity, product availability, and
Security Breach	Shipment control breakdown Unprotected transfer facilities Lax security processes	Employ cargo tracking technology Screen & evaluate vulnerabilities Participate in C-TPAT and FAST	Greater protection against terrorist activity, fewer government inspections, and streamlined border clearance.

Risk Assessment

Risk assessment is an invaluable activity for identifying critical transportation challenges and primary disruption concerns. The output from the Risk Assessment should be used to create a coherent strategy for managing and mitigating transportation risks in a cost-effective manner. The process can include the following outputs:

- The qualitative analysis provides a baseline evaluation of risks in a rapid and cost-effective manner. This approach classifies each risk in terms of low, medium, or high probability and impact.
- Quantitative analysis is warranted for those risks falling into the “Major” risk category. This analysis incorporates numerical estimates of frequency or probability and consequence.
- Risk Assessment Report highlights risk management priorities and “red flag” issues. The output of the report provides:
    1. The relative ranking or prioritization of risks
    2. List of risks requiring immediate response
    3. List of risks for additional analysis and response
    4. Watch list of low priority risks
    5. List of risks grouped by categories

6. Risk trends

International Transaction Risk Management

Transaction risks are various risks that affect both the importer and currency exchange rates for international transactions (David, 2018). The currency exchange rate can be the currency of the exporter's county or of the importer's country or a third country's currency. The choice of a currency rate is a fundamental aspect of international trade.

Theories of Exchange Rate Determinations

a. Purchasing power parity is an economic theory that holds that exchange rates should reflect the price differences of each and every product between countries. The idea is that a set amount of money (regardless of the currency in which it is expressed) would purchase the same goods in any country of the world. The Purchasing power parity theory holds that exchange rates should reflect the price differences of each and every product between countries

Mathematical illustrations:

$$\frac{\text{Spot value of Currency F at time t in Country D}}{\text{Spot value of Currency F at time 0 in Country D}} = \frac{(1+\text{ inflation rate in Country D})^t}{(1+\text{ inflation rate in Country F})^t}$$

or

$$\frac{S(e_t)}{S(e_0)} = \frac{(1+inf_D)^t}{(1+inf_F)^t}$$

b. Fisher Effect is an economic theory that holds that the interest rates that businesses and individuals pay to borrow money should be uniform throughout the world and that the nominal interest rates that they actually pay in a given country are composed of this common interest rate and the inflation rate of that country. In essence, the Fisher effect observes that a country's nominal interest rate comprises inflation rate in country and real interest rate borrowers are paying.

Mathematical representations:

$$(1 + \text{real interest rate}) \times (1 + \text{inflation rate}) = 1 + \text{nominal interest rate}$$

or

$$(1+ \text{rir})(1 + \text{inf}) = 1 + \text{nir} \qquad \text{or} \qquad \text{nir} = \text{inf} + \text{rir} + (\text{inf} \times \text{rir}) \approx \text{inf} + \text{rir}$$

c. International Fisher Effect is an economic theory that holds that the spot exchange rates between two countries' currencies should change in function of the differences between these two countries' nominal interest rates. The International Fisher effect observes that exchange rates reflect the differences between nominal interest rates in different countries.

Mathematical representations:

$$\frac{\text{Spot value of Currency F at time (t+1) in country D}}{\text{Spot value of Currency F at time t in country D}} = \frac{1 + \text{nominal interest rate in country D}}{1 + \text{nominal interest rate in country F}}$$

Or

$$\frac{S(e_{t+1})}{S(e_t)} = \frac{1 + \text{nirD}}{1 + \text{nirF}}$$

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APPENDIX II TECHNICAL REPORT

MARITIME CARGO SECURITY: DATA ANALYSIS AND INTELLIGENT SCREENING

FINAL REPORT

By Mehdi Azimi

September 2020

Introduction

The United States and global economy both are dependent on overseas trade operated by maritime supply chain to a great extent. Every year more than 11.6 million cargo containers from 130 countries enter the U.S. ports. Approximately 90 percent of the global trade (53 percent and 38 percent of the U.S. trade) is shipped via cargo containers (*1*, *2*, *3*). The multi-modal feature of container cargos allows them to enter via a seaport later transported through the roads and rail networks to disseminate deeply into the different regions of the country. Given its huge economic impact on different industries, the concern for securing the maritime supply chain is a justified one. After September 11 of 2001, the concern is heightened due to the vulnerability of the maritime supply chain to the smuggling of illicit goods, terrorist attacks, and other malicious purposes. The goal of this study is to identify the cargo attributes and the potential data mining methods that can be used in a futuristic intelligent screening solution.

Background

Maritime is one of the most important modes of container cargo transportation that plays a vital role in the world's economy. Over 90% of the economic value of global commerce is transported through the maritime domain via containerized cargo. Owing to its speed, cost, and security, containers are the preferred transportation option. With the billions worth of goods coming in and out, ports are served as the center of intermodal transportation. For the same reason, it is prone to smuggling of contrabands, human trafficking, and terrorist attacks. Ports are undoubtedly vital for the economy; and their security becomes more and more important considering negative impacts of potential harms on maritime supply chain.

Ever since the terrorist attacks in September 2001, security has become a national rife. Great emphasis has been placed on securing the borders to minimize any kind of threat. At the same time, it was realized that the country's ports represent a significant vulnerability towards these threats. After September 11, the customs inspectors started to scan more than double the percentages of cargos than before, which made it about 5% of all incoming cargos (*4*), realizing the potential threat they carry. To ensure the security of the border, the U.S. President signed the "Implementing Recommendations of the 9/11 Commission Act of 2007" on August 03, 2007. According to the Act, 100% scanning of US-bound containers at foreign seaports was mandated through the use of non-intrusive imaging (NII) and radio detection equipment. The process of scanning such a huge number of container cargos is very expensive and consumes a lot of time. Even with the application of NII, x-ray, gamma ray and radio detection technology, the inspection of all incoming cargos would be very difficult considering its processing time, financial implications, economic impacts, and insufficient technology. During 2005, the port of Hong Kong estimated a cost of $6.50 per container for scanning which would eventually be falling upon the shippers (*5*). A study showed that installing the facilities in the major ports of the world which were required for the 100 percent scanning would cost around $1.5 billion (*6*). Breaking it down to each container, it would be $15 per container. Also, the total cost of 100% scanning with tamper-proof seals were likely to reach up to $100 per container depending on their number and intricacy of the supply chain.

Furthermore, the inspection delay might risk the containers of missing their predetermined sailings. Mortonosi et al. created a queuing model to estimate delays which would be caused by 100% scanning of import containers (*7*). In the model, the arrival of the containers at the U.S. port entries was assumed to be a Poisson process, and the arriving containers were selected for scanning according to a Bernoulli random process. Averaging all delay results across the 157 ports, the model was concluded that the delay would most likely to increase from 0.5 hours/TEU under the current operations to 5.5 hours/TEU under the regulations of 100% scanning of import containers. It is important to mention that the results from Martonosi et al.'s model were based upon the assumption of all the U.S. imports being scanned on the arrival. However, based on the 9/11 Act, only the U.S.-bound containers are required to be scanned instead which represents a portion of the foreign port's total exports to be scanned before departure. The 9/11 100% scanning legislation Act may be opposed by shippers owing to the increased delays and costs as the major problems (*5*). Instead, a risk-based layered approach of scanning only high-risk containers would ensure both security and efficiency of the supply chain, and would be more supported by the maritime stakeholders. Since the current security controls procedure in place at the ports may not be satisfactory for ensuring the optimum security in the maritime chain, an information system solution to upkeep the security would greatly improve the security with the least impact on current practices. The application of a solution that takes into account the parameters of the cargo information would be ideal. Information is one of the most treasured resources for any business, and Artifical Intelligence (AI) and Machine Learning can exploit this advantage through comprehensive analysis and informed decision-making. They can extract information and uncover meaningful patterns from a complicated and massive amount of data that are too complex to be processed by humans or other conventional computer techniques. Credit card companies and other financial organizations are using it to detect and prevent fraudulent and malicious activities. The top financial companies like Wells Fargo, American Express, MasterCard, and Washington Mutual Banks are using Machine Learning for the greater benefit of their security (*8*). Exact numbers are difficult to produce, but the industry analysts all agree that the use of AI and Machine Learning has enabled these firms to efficiently and effectively prevent fraud activity which in turn benefitted their customers from losing fraud charges on their accounts. The possibility of applying those methods to ensure the security issue is what the situation is demanding.

Research Methodology

A bill of lading (BOL) is a transportation document prepared once a container is full and goods ready to be shipped. The BOL must designate that the properties have been loaded on board or shipped on a named vessel and it must be signed and authenticated by the carrier, or the agent of the carrier. After the terrorist attack of 9/11, the U.S. Customs and Border Protection (CBP) issued new requirements for ocean freight carriers and Non-Vessel Operating Common Carriers (NVOCCs) to report cargo manifests before reaching the U.S. borders. Container ships must report shipment details on each container 24 hours before it is loaded at a foreign port (trucks coming from Canada and Mexico must report their contents from half an hour to one hour before reaching a border crossing point). Therefore, the electronic manifests of all U.S.-bound maritime cargo container data must arrive at Customs and Border Protection's Automated Manifest System 24 hours before the containers are loaded. This manifest contains information regarding the contents of the container, their shipping company, owners, origin, and destination. The manifest contains the following specific data:

- shippers and consignee's complete names and addresses
- description of cargo (including weight and piece count)
- loading port
- last foreign port before the vessel departs for the U.S.
- vessel name, number, country of documentation, Standard Carrier Alpha Code (SACC), and voyage number.
- scheduled date of arrival at the first U.S. port.

- first foreign port where the carrier takes possession of the cargo.
- hazardous material code
- container number
- container seal number (serial number of the last seal applied when the container is loaded)

The information on the manifest must be complete otherwise AMS (Automated Manifest System) rejects it. Vessel operators must include the NVOCCs on their manifests. They must provide accurate and specific information when it comes to the description of the cargos. Generic information such as "chemicals", "electronics", or "foodstuff" is not acceptable. The confidentiality of the manifest is maintained with significance. Data filled before 24 hours of departure are not released until the ship completes its prespecified journey and arrives at a U.S. port. NVOCCs are also required to file their inputs through the ocean carrier.

To facilitate legitimate trade and travel while managing the risk of people or cargo entering or exiting the U.S. who may pose a threat, the CBP has designed and continues to operate the Automated Targeting System (ATS). ATS compares information cargo arriving in, transiting through, and exiting the country against law enforcement and intelligence databases to identify individuals and cargo requiring additional scrutiny. With the information in hand, the program matches with Terrorist Screening Database (TSDB), which ATS ingests from the DHS Watchlist Service (WLS). ATS compares existing information on cargo entering and exiting the country with patterns identified. The patterns are based on the CBP officer experience, analysis of trends of suspicious activity, law enforcement cases, and raw intelligence. ATS evaluates all cargos to identify the amount of risk they possess and eventually single out the high-risk cargos. At present, about 5% of containers are predicted risky enough to conduct a primary scan (*9*). The 95% cargos which are not deemed as high risks are released. Among the 5% which are selected for further inspection, 5% demonstrates irregularities after viewing the scan data (*5*, *9*). Scanned containers which reveal anomalies are taken into the inspection area for physical inspection. A shipment selected by ATS or local CBP officers is held for a non-intrusive inspection. If the CBP officers are unable to resolve the anomaly with a non-intrusive inspection, Officers may refer a shipment for physical examination, which may consist of a visual inspection of the container's interior, a limited inspection of selected contents, or complete unloading of the cargo. Officers also use physical examinations to determine whether a shipment contains undeclared or inadmissible cargo. The CBP analyzes the manifests to select certain containers and trailers to undergo physical inspection. Even these 0.25% of the total US-bound cargo containers which require physical inspection of the highest level requires a significant effort and port resources. Due to the volume of the traffic, it is not feasible to search every single cargo arrives at U.S. port. On average, it roughly takes 15-20 CBP officials around four hours to unload all cargo contents, match them to the provided information of the manifest, and find out what the discrepancy is (*5*). Therefore, the best information and tools available must be identified and applied by the CBP to continually mitigate potential threats and address vulnerabilities. This is where an intelligent historic data based screening system can be effective as the selection process is the most critical in ensuring the security and resilience of the ports. The current cargo screening process still heavily relies on the port official's own knowledge and experiences. Since the task is highly sensitive, the difficulty of converting expert knowledge straight into rubrics that the computer can process, the use of Machine Learning methods that can learn from historical data will be highly beneficial. Therefore, the intelligent screening system will have the potential to filter and identify high-risk cargoes from low-risk ones based on the patterns of some key parameters found in historical data.

The researchers conducted a survey of practitioners to indentify the cargo attribitutes that can be used in the model. The attributes were among the information in BOL and cargo manifest as well as the information related to the vessel and voyage. Based on the survey results, the following parameters were identified as suitable attributes while screening the cargo data in order to detect the malicious cargoes:

1. Port of Origin: The port of origin is a very important parameter while running the primary historical data-based screening. Some ports are less secured than others and are more prone to screening failure. The system will run the screening process based on any history of past malicious cargo detection from the same port of origin and will help the officials to decide if it needs physical inspection.
2. Port of Destination: The Port of destination is also an important parameter since relatively more secured ports are less prone to screening failure. The system will learn how to identify the ports which are more disposed to the security breach and provide a verdict on the necessity of physical inspection.

3. Shipping Company: The shipping company that transports the goods to a destination port is crucial for running an efficient screening because shippers are a critical part of the Maritime Supply Chain. Their potential for involvement with the criminal activity associated with the maritime cargo containers is vital. The relatively new shipping companies, as well as the companies which had a history of such malicious involvement, will go under rigorous scrutiny to ensure the resilience of the maritime supply chain.
4. Exporter and Consignee Party: These two parties of the transaction are the key stakeholders in transporting the container cargoes from one port to another. If any fraudulent or malicious attempt is identified, one or both of the parties can be held responsible. The concerning parties should be aware of transporting any contraband into a port. The previous database will help the law enforcing authority of the port to detect such parties which have a bad reputation regarding such matter and single out the container cargoes for further inspection.
5. Nature of Goods: The nature of the products which are being shipped can help the law enforcer to identify the contrabands. Typically, goods such as electronic items, medicine, food, and vehicles have a higher rate of fraud and carrying contraband. Container cargoes carrying such nature of goods should undergo a higher mode of inspection.
6. Paperwork Error: The system will look for any kind of paperwork error in the manifest submitted by the Shipping company. The container cargoes which comes with significant paperwork error are more likely to attempt fraud or any kind of malicious activity thus require extensive scrutiny.
7. AIS Data: The Automatic Identification System (AIS) is an automatic tracking system that uses transceivers on ships and is used by Vessel Traffic Services (VTS). The AIS data can be used to determine any suspicious activity if they differ from their usual itinerary.
8. Freight Rate: The rate of freight can also be a vital indicator of malicious activity. The cargo containers are most likely to contain contrabands if the freight rate is either too high or too low. Such discrepancies from a regular rate can infer that there might be some underhand business that needs to be physically inspected by the law enforcing authority of the port after the primary screening.

Identifying these attributes provide the opportunity to generate input data for approporiate Machine Learning algorithms. Based on the key parameters, Machine Learning algorithms determine the threat level and the necessity of the cargoes to undergo physical inspection. The difference between supervised and unsupervised Machine Learning is that a supervised learning algorithm takes advantage of labeled samples while unsupervised learning methods usually cluster data points without needing their class (label). Supervised learning methods use observed samples, called training set, to learn (train) the patterns of labeled samples from the available dataset; given a new unlabeled sample, the goal is to correctly classify this new and unseen case. There are many different available supervised learning algorithms that have shown significant results in variety of contexts. The intended datasets for this study will have lables and can benefit from sofistications of the Machine Learning Techniques. For this study, the researchers reviewed four different algorithms: Artificial Neural Network, Decision Tree (particularly C4.5 algorithm), NaïveBayes, and Decision Table. Examining the input data, performance of different techniques and our background expertise made it clear that Artificial Neural Networks are the best approach, as our proposed technique for the project. Neural Networks have highly accurate performances in other similar problems and in different scientific contexts which entitle them as a state-of-art algorithm. Next section elaborates the Neural Networks in more details.

Artificial Neural Networks

Artificial Neural Networks are powerful supervised learning methods which are widely used for prediction and classification. Artificial Neural Networks use the idea of biological neural networks to build models for predictive purposes. Researchers have been trying to build intelligent computer systems that can perform human works and spare humans from tedious tasks or hazardous work environment for a long time. It has been long recognized that human brains are much better and faster at processing and recognizing speech and images than most sophisticated computers. Therefore, the field of Neural Networks began as an approach to imitating and replicating human intelligence for constructing artificial intelligence systems that can learn from experience. Artificial Neural Networks are a network of many simple highly interconnected processing units operating in parallel. The typical Neural Network node has a set of inputs, which are like synapses in a biological neuron. The processing unit responds to external inputs through dynamically changing connection points between the nodes. The processing result is not stored or output to a specific memory location. Knowledge within a neural network is attained through a learning process. After receiving and combining all these inputs, the node needs to transfer these combined values to the next node/layer in the network. Additionally, each node contains an active function or transfer function which informs combined input values to a single value. Mostly, Sigmoid Curve is used as a transfer function. As an example, this activation function can just be to generate a "1" if the summed input is greater than some value or "0" otherwise; this activation function is called Threshold function. Standard, Arctan and Gaussian are some other popular transformation functions. According to Lee and Siau (*10*) Neural Networks try to divide data into mutually exclusive groups with members within a group as close as possible to each other and members of different groups as far as possible from each other. Neural networks handle linear and non-linear mappings. Most popular Neural Networks are:

1. Single-layer perceptron: This class of networks consists of a single layer of output nodes; the inputs are fed directly to the outputs via a series of weights.
2. Multi-layer perceptron: It consists of multiple layers of computational units, usually interconnected in a feed-forward way.

The multi-layer perception is our suggestion for the potential cargo risk prediction. The Neural Network then attempts to automatically find structure in the data by extracting useful features and analyzing its structure. Figure 1 displays the architecture of Neural Networks developed for potential cargo risk prediction.

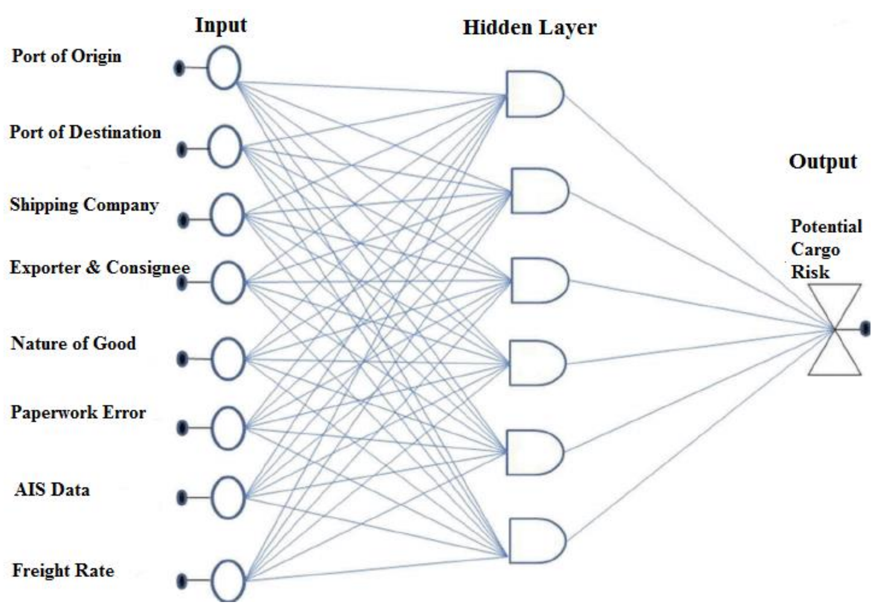

Figure 1: Architecture of Neural Network Developed for Potential Cargo Risk Prediction

Our workflow starts by processing required input data. In order to obtain the most relavant knowledge from selected attributes, the expertise from port officials and maritime practitioners are valuable complement to the system. With this evolving and learning process, several other contributing factors for detecting malicious cargoes may be identified in the future and added to the system. The Artificial Neural Network employ training data to design the model and learn the hidden patterns. Since maritime related data may contain sensitive information of national interest, the real data might not be available for training the model. A common practice to resolve the aforementioned issue is to use sysnthetic data, which is generated according to the requirements of real-world information. Once the data is cleaned, organized, and validated, the importance of each factor will be analyzed. Next, preliminary training and testing cases are generated to determine the network configuration. Complete training and testing cases are developed and implemented toward the end of this phase. Finally, the output results derived from the networks are evaluated and interpreted. The system may be put into practice using new data to effectively predict outcomes related to contraband detection. These predictions may need to be manually validated using historical data and human experience. One of the greatest advantages of delveoping the artificial systems is its robustness and reproducibility. These two chasteristics, which embrace changes, make our proposed system a great tool for monitoring cargo system.

In order to implement the workflow as a prototype software system bu the DHS, there are multiple options available. We suggest employing the TensorFlow platform empowered by Google (*11*). TensorFlow is free, open-source and multi-platform. The flexibility and large incorporated libraries make TensorFlow one of the most popular Artifical Intelligence and Neural Network implementations choices. TensorFlow can be used in different Operating Syatems, including Mac OS and Windows, and is used for programming in mobile devices running Anroid or iOS system. The TensorFlow is based on Python libraries, thus, takes advantage of many embedded machine learning capabilities in that programming language. The high-level API's and ease of use make TensorFlow programming a more straightforward process.

Finally, after implanting the software prototype by the DHS, we suggest employing the system to a secure Supercomputer system. We anticipate that the volume of our input data increases largly (possibly exponetially), after releasing the system to the practitioners. There will be more ports, and numerous vessels and cargo added to the system during its lifetime. Thus, the Big Data challenges should be anticipated and addressed. One of the solutions is to employ the system on a High-Performance Computing (HPC) environment, also known as supercomputer setting. The HPC system not only can run the software in fraction of time, but also are equipped with large storage data to host generated cargo data.

Summary and Conclusion

This report analyzed the cargo security challgenes and provided a solution. We examined the issues by using background studies and gathering information from practitioners. Then, we focused on the cumulative data and selected the most relavant information. We used the selected cargo attributes as a guide to establish a system based on the concepts of Artificial Intelligence. Our research shows that Artificail Neural Networks are the best approach for cargo security screening system. The suggested Artificial Neural Network learns hidden patterns in the data based on our chosen features and can predict future threats. Finally, we provided the practical computational tools to implement the system.

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APPENDIX III TECHNICAL REPORT

SECURE AND EFFICIENT MARITIME DATA STORAGE AND RETRIEVAL

Final Report

By Ismet Sahin

September 2020

SECTION 1.

Project Aims and Summary of Achievements

Recent large-scale cybersecurity attacks to shipping companies and ports have increased the need for *research and development of secure online data management systems* and also the need for *creating new courses* in universities to graduate students who are aware of cybersecurity threats to marine information systems and know how to reduce the harm due to malicious attacks. The first objective of this project is to research new ways of increasing the security of data access and modification in marine systems without reducing the efficiency of network applications. The second objective is to develop a new course on marine cybersecurity.

When a maritime computer system is connected to the Internet, the system becomes available to its administrators and users but also malicious attackers. Recent cyberattacks demonstrate that the attackers are more often using phishing methods in gaining access to the target system, encrypting the important system files, and then demanding money from the target [1]. This type of attack is called *random attacks* that have been happening to multiple maritime companies including the world's biggest shipping company A.P. Moller Maersk. The Maersk's computers were infected by malware in June 2017 and the estimated cost of this attack was as much as $300 million.

To minimize the harm caused by ransom attacks to the maritime storage systems, our approach has been to prevent these types of attacks in the first place. However, prevention of the attack requires additional information processing and this processing should not cause any delay in maritime operations. To obtain such a system we focused our attention on using machine learning methods that learn from historical datasets and then use this knowledge for estimating malicious entities and warning maritime system administrators before they provide their important system-access credentials to these entities.

Many successful machine learning algorithms in the literature are used in modern artificial intelligence applications and two of them are particularly effective, namely, the K-Nearest Neighbors (KNN) algorithm and the Neural Networks (NN). Our research effort resulted in a highly accurate new KNN algorithm, called Exponentially Weighted KNN (EWKNN) that uses exponential weights for accounting the contributions of neighbors in the classification decision that is in contrast to the simple voting mechanism of the standard KNN algorithm. We applied this new algorithm to a cybersecurity dataset that had thousands of malicious web addresses that had been used in malicious cyberattacks and also thousands of benign web addresses and EWKNN had the highest classification accuracies of detecting the malicious web sites compared to the existing derivatives of KNN algorithms.

Our other research effort was to improve the optimization algorithms that are used in neural networks. Most of the current neural networks use deterministic derivative-based optimization algorithms that work well when objective functions are smooth and have only one optimum point. However, the objective functions for neural networks often have many optimum points and the deterministic algorithms are capable of finding the closest optimum point to the initial guess point. The closest optimum point can be very suboptimal that the resulting neural network may not achieve the highest possible classification accuracy. We focused our attention on non-derivative based stochastic optimization algorithms, in particular to Random Lines (RL) algorithm. We proposed a new RL algorithm that outperformed the standard RL algorithm substantially and published this approach in [2]. In a future project, we would like to continue this line of research by using the improved RL algorithm in NN and then apply this new system in detecting malicious web site addresses used by malicious actors.

Besides the above research effort, after carefully shaping the course content, we proposed a new course titled "MTMS 448 - Introduction to Maritime Cybersecurity" and it was accepted by the Curriculum Committee at the Texas Southern University. As the name suggests this course aims to teach principles of modern cybersecurity and in particular its application to maritime information systems. We enjoyed substantial support from our collaborators at the Stevens Institute of Technology in preparation of the content of this course.

The following sections will elaborate on three pieces of contribution to the maritime cybersecurity field: (i) the methodologies and research results for effectively using machine learning algorithms to recognize malicious entities automatically, (ii) the methodologies and research results for improving stochastic optimization algorithm RL that is capable of improving the effectiveness of the machine learning algorithms, and (iii) development of a course that aims to teach students about maritime cybersecurity principles.

SECTION 2.

Automatic Detection of Malicious Attacks Using Machine Learning Algorithms

Part 2.1 Introduction

Today's maritime computer systems provide many important services to their users. They handle private communications with multiple entities, obtain weather conditions and find the best possible routes, avoid collision with the other ships in their vicinity, provide information about the weights of different cargo for effective loading and unloading, etc. An interruption to these services may result in catastrophic events. In particular interruption to obtaining current weather conditions and avoiding dangerous water conditions or pirate ships may cause large damages. Therefore, preventing cyber-attacks that disable the functionalities of these systems is very critical and our research focuses on automatically recognizing malicious entities and warning the marine system administrators before they interact with these dangerous entities.

A malicious attack may happen through a brute-force attack or a phishing attack [3]. In the former case, the attacker carefully selects a target, gathers information about the target from social networks and other resources, and then uses this information along with the most frequently used passwords or the passwords chosen from dictionaries to access into the target's computer system. This type of attack requires a high level of computer skills and a large number of resources, effort, and time; therefore, it is not used frequently. In another type of attack, the attacker follows a very simple scheme that solely relies on deceiving the target. In this case, again the attacker gathers as much information about the target as possible, and crafts an email that looks very similar to legitimate emails and attaches a malicious piece of program to this email that is activated by clicking a link or by opening the attachment, and then sends this email to the target. To increase the credibility of the email, the attacker uses information that he/she gathered in the email by specifying the target's work responsibilities or the subjects that the target is interested in. Opening this email, or clicking the link in it, or opening the attachment does result in the installation of the malware whose sole purpose is to allow the attacker to have unlimited access to the target's computer system.

Recent cyber-attacks demonstrate that the attackers are more often used the phishing method in gaining access to the target system than the brute-force attacks. Once the attacker has full access to the target's system files, he/she encrypts the important files and then demands money from the target [1]. When the money is paid to the attacker, the attacker may choose to decrypt the system files or may not. This type of attack is called a *ransom attack*. Instead of demanding money, in some cases, the attacker obtains the critical information to wire money from the target's bank account to the accounts that are under his/her control.

Cyber-attacks are rapidly rising in recent years. There were more than forty thousand Business E-mail Compromise (BEC) and the E-mail Account Compromise (EAC) attacks between October 2013 and December 2016 that resulted in the loss of more than five billion dollars [1]. The targeted entities were mostly the banks and other financial institutions in various countries, but most prominently in China, Hong Kong, and the United Kingdom. The financial loss grew 2,370% between January 2015 and December 2016 due to BEC/EAC attacks.

An effective solution to this problem is to educate people about ransom attacks and reduce the number of harmful incidents. In addition to education, an automated pattern recognition system can fortify the defense system substantially. The automated system uses machine learning models that are trained on large datasets with many examples of malicious and benign web site addresses and then uses the trained model for estimating newly provided web site addresses as malicious or benign. For this research, we used a large dataset with 5721 web addresses where each web site address is associated with 30 attributes [4].

The literature has multiple recently proposed machine learning methods to recognize malicious cyber entities. The authors of the paper [5] used Support Vector Machines (SVM) for detecting malicious links automatically where each website address also had multiple attributes including the *link popularity* attribute. Even though the link popularity attribute is highly discriminative, it does not exist for newly created malicious websites, or its value is largely varying through different search engines. The dataset used in this paper does not have the link popularity attribute. Two other machine learning algorithms, namely The Neural Networks [6] and Rule-based classification methods [7], are also used in detecting malicious web sites. None of the above studies used QDA nor the KNN algorithms, both of which are well-known and successful classification algorithms.

This research uses the original KNN algorithm and its three well-known weighted variants in detecting malicious web sites. KNN is one of the most used models in modern artificial intelligence applications because its accuracy is asymptotically optimal, implying that it yields the least possible error rate [8]. The first KNN variant is the Weighted KNN algorithm which assigns larger weights to the closest neighbors of a given test point. This allows the closer neighbors to have larger impacts on determining the class of the test point or test web site address. It usually achieves higher accuracy rates than classical KNN. The second variant is the Dual Weighted KNN which has a very similar weighting scheme to WKNN. The third variant, referred to as 1/D KNN here assigns weights which are inversely proportional to the distances from the test point to the nearest neighbors.

In this research project, we present a new weighting scheme, called the Exponentially Weighted KNN (EWKNN), that uses an exponential decay function to assign weights that reduce exponentially as the distances to the neighbors increase. The accuracy rates of the new approach are often higher than the above KNN variants and the QDA (Quadratic Discriminant Analysis) algorithm, which is another well-known classification algorithm. The EWKNN algorithm requires a training session that needs to be performed only one time to find optimal exponential decay constants, and then it is ready to classify any given new test points.

The classical QDA algorithm is also included in this research for comparing its accuracy and false-negative rates with the proposed method. The QDA algorithm often yields smaller false negative rates at the cost of yielding substantially lower overall classification accuracies. A false negative corresponds to classifying a **malicious web site** as a benign one, which is highly risky as it may lead to harmful results. When we compare the EWKNN with QDA at the fixed classification accuracies, EWKNN achieves smaller false negatives.

Part 2.2 Performance Evaluation

This section presents the accuracy rates, true positive rates (TPR), true negative rates (TNR), false-positive rates (FPR), and false-negative rates (FNR) of the algorithms KNN, 1/D KNN, WKNN, DWKNN, and the proposed algorithm EWKNN. The same metrics for QDA are also computed for comparing its performance with the KNN algorithms. The rates are obtained by using the k-fold cross-validation method with $k = 10$. This choice of k is empirically shown to have lower bias and a smaller variance of estimation [8]. In this validation, all data instances are split into 10 groups and each group becomes the testing set in turn while the remaining 9 groups are merged to constitute the training set. This way every web site address in the dataset becomes a test point once.

The performance rates are computed based on the dataset at the UCI Machine Learning Repository [3]. This dataset has 30 attributes for each URL. Some of the attributes take the values of +1 or -1 while others take the values of +1, -1, or 0. Labels are either malicious or benign. The attributes include whether request URLs exist or not, whether the function mail() exists on the server-side, the URL includes the hostname or not, the number of redirecting is large or small, whether the right click is disabled in the web site, pop-up windows with text fields exist or not, etc. For all of the attributes and their descriptions, see the dataset description at the repository.

As can be seen from Fig. 1, EWKNN achieves higher accuracy rates than the other KNN algorithms through almost all K values which refer to the number of closest neighbors under consideration – this K is different than the K variable used in the k-fold cross validation above. The accuracy rates for all algorithms rapidly increase when K reaches the value of 4 and then continue to increase slowly until K = 10 for WKNN, DWKNN, and EWKNN. The other two algorithms demonstrate degradation in accuracy for larger K values. The accuracy rate of EWKNN is 0.9465 when K=10 and its accuracy remain above 0.94 for all K > 10. The authors of [5] who used the same dataset reported that the highest accuracy rate was 0.9248 with a neural network model. Even though EWKNN has a slightly larger accuracy rate, the difference corresponds to about 124 more number of correct classifications. Note that each erroneous decision may lead to having a large negative impact.

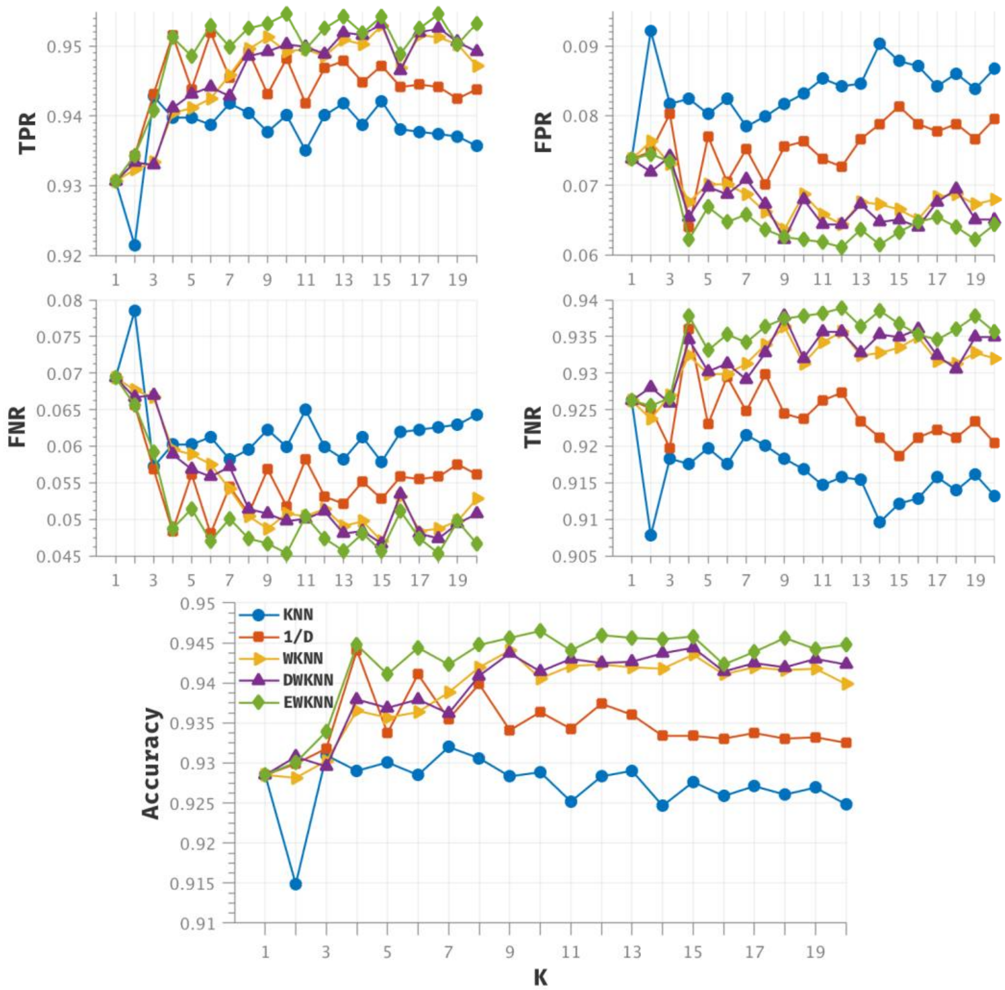

Fig. 1. True Positive Rates (TPR), False Positive Rates (FPR), False Negative Rates (FNR), True Negative Rates (TNR), and accuracy rates against the number of the nearest neighbors (K) are plotted for the KNN algorithms. The legends of all plots are the same as specified within the accuracy plot.

Table 1. Number of classification errors for the KNN algorithms as K varies from 1 to 20

K	KNN	1/D	WKNN	DWKNN	EWKNN
1	409	409	409	409	409
2	487	401	411	396	400
3	395	390	399	403	378
4	406	320	363	355	316
5	400	379	368	361	337
6	409	337	364	355	318
7	389	369	350	365	330
8	397	344	332	338	316
9	410	377	320	322	311
10	407	364	340	335	306
11	428	376	331	326	320
12	410	358	330	329	309
13	406	366	332	328	311
14	431	381	333	322	312
15	414	381	323	318	310
16	424	383	337	335	330
17	417	379	332	329	321
18	423	383	334	332	311
19	418	382	333	326	319
20	430	386	344	330	316
AVE	415.5	373.3	349.3	345.7	329.0

The EWKNN algorithm also demonstrates higher performance rates over the four categories as it has higher true positive and true negative rates and smaller false negative and false positive rates than the other KNN algorithms. In particular, having smaller false-negative rates is an important property.

Table 1 lists the number of classification errors made by the KNN algorithms. The number of errors is found by adding the number of false negatives and false positives. The EWKNN algorithm has the smallest number of errors over every K values except that DWKNN has a smaller number of errors when K=2. The proposed algorithm's number of errors is 329 which is approximately 16 less than that of DWKNN, and 20 less than that of WKNN on average.

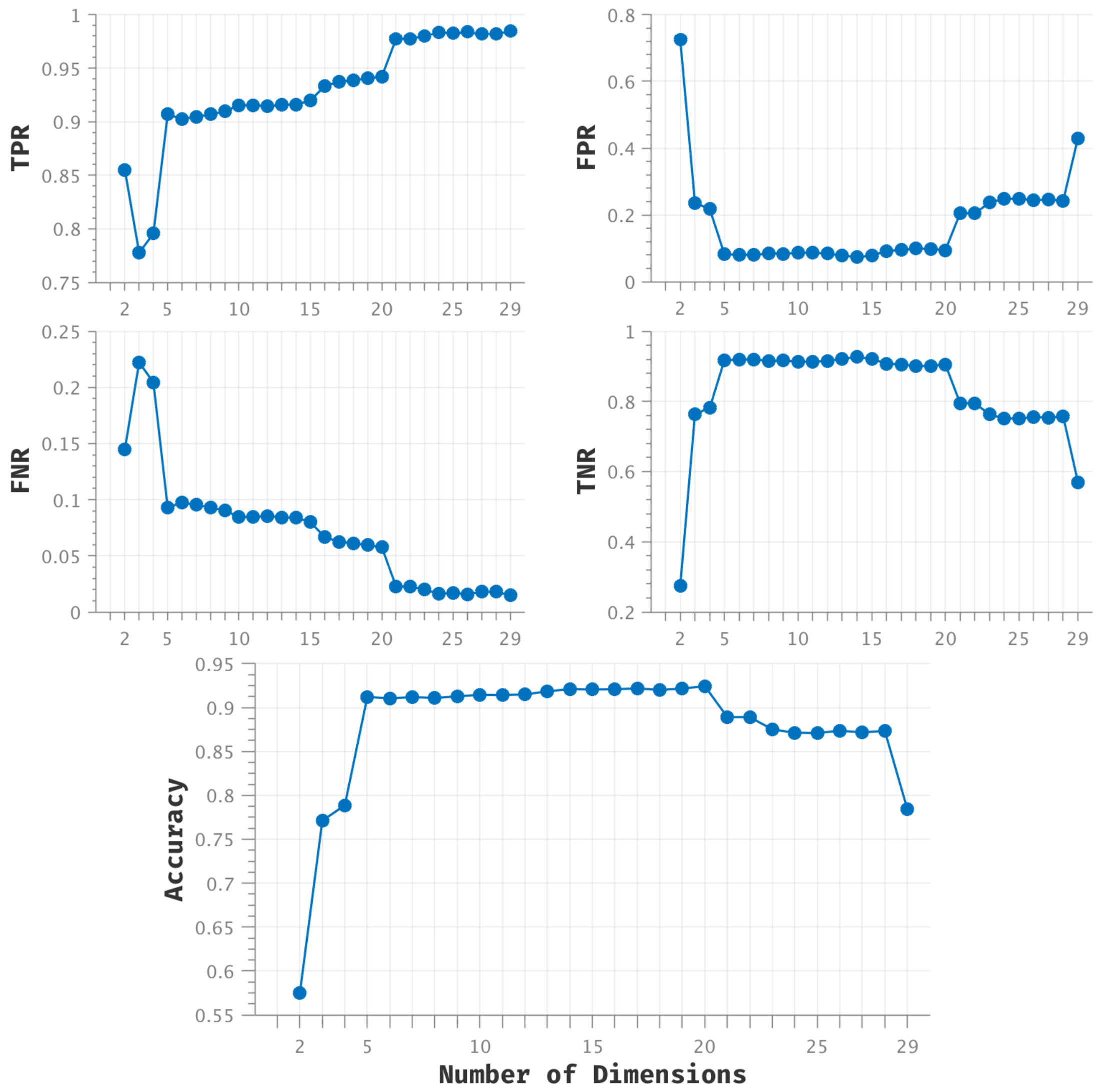

Fig. 2. True Positive Rates (TPR), False Positive Rates (FPR), False Negative Rates (FNR), True Negative Rates (TNR), and accuracy rates for the QDA algorithm when the problem dimension is reduced from 30 to a number in the range 2 to 29.

Since false-negative rates of QDA are often lower than the above KNN algorithms, we included the results of this algorithm in this paper. A good description of QDA can be found in this book [9]. This algorithm requires the inverse of covariance matrices. The covariance matrices for two classes in this study were almost singular, as a result, finding their inverses were not possible. For this reason, the problem dimension is reduced from 30 to a smaller number of dimensions to obtain non-singular covariance matrices by using the Principle Component Analysis (PCA) [10].

Fig. 2 shows the performance rates achieved by QDA for problem dimensions ranging from 2 to 29. The best accuracies are obtained when the problem dimension is reduced to the numbers between 5 and 20. Outside of this range, the accuracy rates are substantially lower. When the problem dimension is between 5 and 20, QDA's accuracy and false-negative rates are approximately 0.92 and 0.06 respectively while EWKNN's corresponding rates are 0.946 and 0.04 which are more favorable. When the problem dimension is larger than 20, QDA achieves a much smaller false-negative rate of 0.017 but its accuracy reduces to 0.87, which is a substantial reduction.

Part 2.3. Conclusion

A new weighted KNN algorithm for detecting malicious web sites used in ransom attacks, called the EWKNN algorithm, is proposed. The new algorithm uses exponentially decaying weights in determining whether a web site is malicious or benign. The algorithm depends on the decay constant whose optimal value is found by maximizing an objective function. The objective function has the property of having larger values for higher classification accuracies. As the objective function is not differentiable, a grid search is performed to find the optimal parameter values. By using a real dataset containing a large number of malicious and benign web sites, the proposed algorithm achieves higher performance than the other KNN algorithms. Since QDA is capable of yielding smaller false-negative rates, its performance is also compared with the proposed method and the proposed method achieved higher classification accuracies than QDA. When accuracy levels are fixed, the proposed algorithm achieves a smaller false-negative rate than that of QDA. A future study is going to focus on how to reduce the computational effort in finding the optimal decay constant.

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SECTION 3.

Stepping Away from Maximizers in Random Lines Algorithm

Part 3.1 Introduction

Automatic malicious web site address detection involves a large number of web site attributes and obtaining a machine learning model for them may be challenging due to discontinuous objective function and also due to the existence of a large number of optimum points. In this case, most of the deterministic algorithms become unavailable for finding an optimum machine learning model such as neural networks. This type of optimization task can be achieved by using derivative-free stochastic optimization algorithms and population-based algorithms are a family of such algorithms.

Population-based stochastic optimization algorithms aim to find an extremum of a given function defined in a region of interest. The ease with which the population-based algorithms can be implemented and applied to problems has resulted in their extensive use and development [1, 2, 3]. They are often used when the objective function does not have gradient or Hessian readily available, perhaps due to its complexity, discontinuity, or non-numeric structure. While other approaches exist for these types of problems such as direct search methods [4] and simulating annealing methods [5], this research project focuses on a population-based algorithm using quadratic functions.

Quadratic function approximation is an important technique that is used in many optimization algorithms. For instance, the Newton-Raphson method uses the minimizer of a quadratic approximation as the next best guess [6]. A quasi-Newton algorithm described in [7] finds a descent direction based on the BFGS (Broyden–Fletcher–Goldfarb–Shanno) Hessian update and performs an inexact line search in this direction by using quadratic and cubic interpolations. Similarly, the line search method in [8] also uses quadratic functions. Besides these deterministic algorithms, the stochastic algorithm Controlled Random Search has a mutation operation based on quadratic functions [9]. A similar mutation operator for the Differential Evolution (DE) algorithm is also proposed in [10]. Local quadratic search is combined with random mutations to increase the robustness of an evolutionary multi-objective algorithm in [11]. Quadratic functions are also used in recently proposed stochastic optimization algorithms in [12, 13, 14, 15].

The Random Lines (RL) search algorithm tries to learn the cost function surface by fitting quadratic functions to the points over randomly selected lines in the function domain. Some of these quadratic functions may be convex while the others are concave. The algorithm makes use of the minimizers of quadratic functions whenever they are convex. However, when they are concave, the existing RL algorithms either simply use the maximizers of the concave quadratics [16] or take a fixed-size step from an initial target point [17].

This research project proposes a new approach that handles the concave cases to achieve more efficiency and robustness in minimizing functions than the existing approaches in [16] and [17]. Previously, a step was taken from always the starting parent point that is one of the three points defining the line for the single-dimensional quadratic function. Since the function values at three different points are known for constructing the quadratic function along a line, the new approach presented in this paper chooses the point with the least function value as its starting point for this line. Then, it takes a random-length step in the direction that is away from the maximizer of the concave quadratic function along the line. The necessary mathematical expressions defining the direction away from the maximizer from any given point along the line are obtained and used in the implementation of the algorithm. Finally, the new approach uses an extended selection operation in which the sampled points are also considered for being chosen into the next generation. Previously, only the mutated points were considered for selection to the next generations.

Part 3.2. Performance Analysis

In this section, the performance of the proposed RL is compared with the original RL [17] and the three well-established population-based evolutionary algorithms, which are the Differential Evolution (DE) [18], the Particle Swarm with constriction (PS) [19], and the Adaptive Differential Evolution with Optional External Archive (JADE) algorithms [20]. In this paper, the DE/rand/1/bin variant is considered as it is also used in [18, 21, 22, 23] due to its robust and fast-convergent characteristics.

The population size of $n_P = 20n$ is also used by all the algorithms where n is the dimension of a cost function. Each algorithm minimizes each cost function 30 times and all algorithms use the same initial population at the beginning of each run for a fair comparison. Note that different runs have different initial populations. All the algorithms use the fixed crossrate constant of $\rho_{CR} = 0.9$ except that JADE uses a dynamic constant that changes through generations. The JADE algorithm also uses two constants $c = 0.1$ and $p = 0.05$ as described and used in [20]. The DE algorithm uses the vector scaling constant of $\rho_F = 0.5$ which is also used in [18, 21, 22]. The PS method described in [19], where the default constriction constants $c_1 = 2.8$ and $c_2 = 1.3$ are used, is implemented here for the comparisons. The RL algorithms assume that a quadratic function $\phi(\mu)$ is convex if $a > \epsilon_{convex}$, otherwise it is concave, where $\epsilon_{convex} = 10^{-12}$ for robustness in numerical computation. The other two fixed constants for the RL algorithms are $\mu_1 = 0.0001$ and $\mu_2 = 0.3$.

The same stopping criterion is used for all of the algorithms. An algorithm is said to be successful if it finds a point x_{best} satisfying $f(x_{best}) < f(x_*) + 10^{-5}$ where x_* is a known global minimizer of $f(x)$. The algorithm is unsuccessful if either of the following two conditions holds: (1) the algorithm cannot find a satisfactory point after 3,000,000 function evaluations or (2) it cannot improve the best function value over 200 generations. It is said that there is an improvement in the best function value when $f_{best\_prev} - f_{best\_current} > 10^{-6}$ where f_{best_prev} and $f_{best\_current}$ are the best function values for a previous generation and the current generation, respectively.

The performance of the optimization algorithms is tested over 50 cost functions that are listed in Table 1. The top 36 functions are specified in [17] while the remaining ones are the first 14 cost functions in CEC 2005 [24]. The table includes separable and non-separable and also unimodal and multimodal functions. Extendable functions including the CEC functions are minimized when their problem dimensions are 2 and 10. The dimensions of the functions are specified in the parenthesis following their names. The total numbers of successes (NS) are listed as the measure of robustness and the average number of function evaluations (NF) are listed as the measure of efficiency. When an algorithm fails to converge for all 30 runs for a particular cost function, asterisks ** are placed on the row for this function, meaning that the average number of function evaluations for this cost function is not defined.

Instead of assuming that the distribution of the number of function evaluations required to successfully converge to a minimizer over 30 runs is normal, no assumption is made for the form of the distribution. This leads to the use of a non-parametric statistical hypothesis test known as the Wilcoxon signed-rank test at the 5% significance level in this paper [25].

The final rows of the tables quantify the overall efficiency of the compared algorithms by averaging a performance index that is defined here. Since the average number of function evaluations can largely vary over different cost functions, their mean value can be largely affected by a few outliner costs functions. To reduce their effect on the final average value, the number of function evaluations is represented in percentages with respect to a reference algorithm A. Let $n_{FE,A}$ and $n_{FE,B}$ be the average numbers of function evaluations of the reference algorithm A and an algorithm B for a cost function. The algorithm B is said to be c_B percent more efficient than the algorithm A, where c_B is defined as

$$c_B = \begin{cases} \dfrac{n_{FE,A} - n_{FE,B}}{n_{FE,A}} \cdot 100 & n_{FE,A} > n_{FE,B} \\ -\dfrac{n_{FE,B} - n_{FE,A}}{n_{FE,B}} \cdot 100 & n_{FE,A} \leq n_{FE,B} \end{cases}$$

Notice that c_B can take negative values whenever the reference algorithm A is indeed more efficient than B. In this case, it is said that A is $|c_B|$ percent more efficient than B, where |.| is the absolute value operator. For instance, if $n_{FE,A} = 82$ and $n_{FE,B} = 100$, then $c_B = -18$, then A is 18 percent more efficient than B. Notice that the possible values of this index are between -100 and 100. The cost functions with two asterisks are not accounted for the average percentages in the final rows.

Table 1 lists the results achieved by the original RL algorithm [17] and the RL algorithm proposed in this paper over the cost function whose dimensions range from 2 to 6. Out of 1500 minimizations, the improved RL successfully finds global minima for 1486 runs, which is slightly more robust than the original RL's 1469 successes. The improved RL algorithm converges for all runs over 47 cost functions whereas this number is 42 for the original algorithm. This is easily noticeable in Figure 3.a where new RL's NS deviates from 30 at 3 cost functions while the original RL deviates at 8 different functions.

The new RL algorithm is also substantially more efficient than the original algorithm as its average performance index is 23.8% from the last row of Part 3.5. ***Appendix***

Table 1. The improved RL is more efficient over 45 cost functions meanwhile the original RL is more efficient for 3 functions, they have the same function evaluation counts for the remaining 2 functions. This trend can also be seen in Figure 3.b where new RL's normalized function evaluation counts are larger than original RL's for only three cost functions and they have similar function evaluation counts for 12 cost functions. However, the new RL achieves much higher efficiencies for the remaining cost functions. In particular, if we count the occurrences of new RL's normalized NFs being below the line of 0.6, we see that it is more efficient than the original RL by at least 40% for 10 cost functions. The Wilcoxon signed-rank test shows that the new RL algorithm requires significantly a smaller number of function evaluations than the

original RL over 29 cost functions while the original RL is not significantly more efficient than the new RL for any of the cost functions.

The performance of the improved RL algorithm is also compared with the three well-known population-based optimization algorithms DE, PS, and JADE in Table 2 over the same cost functions presented in Part 3.5. ***Appendix***

Table 1. The RL's total number of successes of 1486 is slightly higher than JADE's 1465 successes and is substantially higher than the DE's 1356 and PS's 1368 successes. This trend can also be easily seen in Figure 4.a where RL's number of successes remains at the level of 30 or slightly below that level while others have large deviations from 30.

Table 2 summarizes the relative efficiencies of the algorithms with respect to the DE algorithm. The RL algorithm is more efficient than DE by 23.3%, whereas PS and JADE are 3.5% and 18.2% less efficient than DE. The normalized function evaluation counts in Figure 4.b shows that RL's function counts go above the reference line for 10 cost functions; however, its counts are below the reference line for the remaining functions with relatively larger margins than the other algorithms.

Table 3 statistically compares the average number of function evaluations over the 50 functions of Table 2. The RL algorithm requires significantly a smaller number of function evaluations for 31, 28, and 37 cost functions than DE, PS, and JADE, respectively. The algorithms DE, PS, and JADE are significantly more efficient than RL for 4, 4, and 2 cost functions, respectively.

The medians of best (minimum) function values achieved through generations are plotted in Figure 5 for even-numbered cost functions of Table 2, where the first row of plots belong to the cost functions on the rows 2, 4, 6, 8, and 10 of Table 2. Since RL needs two function evaluations during each generation, the horizontal axis is stretched twice for the RL plots for a fair comparison. The result is that each algorithm performs the same number of function evaluations during each generation in this figure. For instance, RL's median function values shown in the subplot on the 3rd row and 5th column was indeed achieved within 23 generations but it is stretched to 46 generations in the plot. Overall, RL achieves fast reductions in function values except for the 26th and 42nd functions. In particular, its best function values demonstrate sharp reductions compared to the other algorithms for the cost functions on rows 6, 20, 30, 32, 38, 40, 46, and 48 of Table 2.

When the cost function's problem sizes are increased to 10, the JADE algorithm has better performance than the others in general as seen in Table 4. The last 8 CEC functions are not included in this table as almost none of the algorithms have successes for these functions. The JADE algorithm is the most robust with 377 successes which are slightly larger than RL's 374 successes and DE's 361. The PS's 235 successes are substantially smaller than the others. Similarly, the overall efficiency of JADE is better than the others as it is 51.8% faster than DE while RL is 24.6% faster than DE. Even though PS achieves the fastest overall convergence with 61.5%, it fails more frequently to converge than the other algorithms.

Table 5 lists the significance test results for the average number of function evaluations listed in Table 4. The JADE algorithm is significantly more efficient than DE and RL over 11 and 9 functions, respectively. RL is significantly more efficient than DE and JADE over 9 and 3 functions. JADE is the most efficient algorithm in general for these higher dimensional cost functions.

Table 6 lists the average best function values achieved after performing 99,800 function evaluations for the same 10-dimensional cost functions of Table 4, including all 14 CEC functions. The JADE algorithm achieves the smallest function values for the largest number of cost functions compared to the others. It can have function values less than 1e-4 for 13 functions while RL and DE achieve such function values for 9 cost functions. The Wilcoxon signed-rank test results listed in Table 7 show that JADE leads in achieving significantly smaller function values than DE, PS, and RL for 17, 10, and 15 functions, respectively. The RL algorithm follows JADE by achieving significantly smaller function values than DE, PS, and JADE for 13, 13, and 4 functions, respectively.

Part 3.3. Discussion and Concluding Remarks

The original RL algorithm fits a quadratic function to three points along a randomly chosen line and uses the minimizer of the quadratic function whenever it is convex. Two contributions of this paper are, whenever the quadratic function is concave, (1) instead of always starting from a target parent point, start from the best point out of the three points on the line where the best point is the one with the smallest function value, and (2) the direction of the step from the best point is determined based on the derivative of the quadratic function at the best point in a way that the followed direction is away from the maximizer of the quadratic function. Minimizations of 50 cost functions are performed with the improved RL and the original RL algorithm and the improved RL has faster and slightly more robust performance than the original RL algorithm. Similarly, the improved RL is substantially more efficient and robust than three other population-based algorithms in the literature for the lower-dimensional cost functions.

When the problem dimensions are increased to 10, the proposed algorithm is less efficient and slightly less robust than JADE. The JADE algorithm is significantly faster than RL for 15 functions while RL is faster than JADE for only 4 functions. The quadratic functions may be more accurate in modeling lower-dimensional cost function surfaces than the higher dimensional ones. As a result, RL's performance falls behind JADE as problem dimensions get larger.

Even though multiple ideas on the step size were considered, a randomly sized step yielded more robust and efficient results. More specifically, the step $\mu_{rand}p$ was taken to determine the mutated point $x_* = x_{start} + \mu_{rand}p$ where μ_{rand} had a uniform distribution between 0 and 1. Thus, the length of the step was between 0 and p_{len} which was the length of p. Instead of this randomly sized step, a step size p_{ave} was also used, where p_{ave} was the average of all the directional vectors p over every line within each generation. In another modification, p_{slope} was used, which was inversely proportional to the slope of the quadratic function at the starting point. This would allow the algorithm to take a smaller step when the slope was large which may have been due to large changes in the underlying function value. Similarly, a larger step was taken whenever the slope at the starting point was small. Overall, the random step performed better than the average step p_{ave} and the slope-dependent step p_{slope}.

The proposed algorithm is only concerned with the minimization problems without constraints on their control variables. It can be extended to the problems with constraints through some well-known approaches that are applied to mutated points. For instance, mutated points can be moved back to a feasible point along their lines or they may be projected onto the surface of the feasible region.

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Part 3.5. Appendix

Table 2 *The numbers of successful runs (NS), the average numbers of function evaluations (NF), and the standard deviations of NF are listed for the original RL and the proposed RL algorithms. The improved efficiency in NF of the proposed algorithm is listed in the parenthesis following NF. Each cost function is minimized 30 times. Problem dimensions are specified within the parentheses following the cost function names.*

	RL ORIGINAL			RL AWAY FROM MAX		
CostFunctions	**NS**	**NF(%)**	**STD**	**NS**	**NF(%)**	**STD**
Alpine(5)	30	24647(0)	6123.99	30	15900(35)	3263.17
Bard(3)	30	4632(0)	1385.29	30	2628(43)	301.61
Becker(2)	30	643(0)	212.79	30	624(3)	200.58
Branin(2)	30	365(0)	91.42	30	355(3)	62.79
Brown(2)	30	4432(0)	1054.29	30	4091(8)	355.6
Camel3(2)	30	528(0)	115.74	30	485(8)	110.54
Camel6(2)	30	899(0)	157.14	30	811(10)	121.57
Colville(4)	30	16341(0)	5700.77	30	10315(37)	3831.14
Cubic(2)	30	6670(0)	2285.13	30	4101(39)	1106.46
Dejon4(5)	30	1327(0)	125.76	30	1347(-1)	135.78
Dekker(2)	30	1299(0)	176.91	30	1037(20)	143.62
Easom(2)	30	2017(0)	476.02	30	1035(49)	142
Exponential(5)	30	2260(0)	294.31	30	2240(1)	190.46
Freudenstein(2)	30	1982(0)	580.72	30	1608(19)	569.81
Gaussian(3)	30	9675(0)	1918.41	30	4756(51)	1070.41
Goldstein(2)	30	1051(0)	186.15	30	941(10)	129.39
Gulf(3)	30	4000(0)	1144.51	30	2656(34)	786.25
Hartman3(3)	30	1652(0)	229.28	30	1392(16)	170.73
Hartman6(6)	30	10248(0)	1995.48	30	8784(14)	1270.51
Helical(3)	30	3016(0)	527.78	30	2548(16)	375.44
Hyperellipsoid(5)	30	3733(0)	589.84	30	3707(1)	554.56
Jennrich(2)	30	2365(0)	345.78	30	1707(28)	201.6
Kowalik(4)	26	29949(0)	33932.8	23	33750(-11)	43398.17
Levy1(5)	30	4553(0)	718.11	30	4327(5)	577.11
Matyas(2)	30	224(0)	63.55	30	221(1)	59.17
Miele(4)	30	3520(0)	735.92	30	3307(6)	704.46
MultiGaussian(2)	27	4657(0)	2182.48	27	2926(37)	1163.11
Periodic(2)	30	2607(0)	916.38	30	2059(21)	770.11
Powell(2)	30	11984(0)	3931.17	30	7093(41)	2730.21
PowellsQ(4)	30	2768(0)	575.2	30	2571(7)	431.96
Schaffer2(2)	30	9884(0)	764.49	30	5587(43)	268.5
Shekel5(4)	30	7796(0)	1751.11	30	5216(33)	1447.86
Shekel10(4)	30	7339(0)	1129.41	30	4896(33)	1137.87
Step(5)	30	2327(0)	476.04	30	2233(4)	349.71
Wood(4)	30	16283(0)	5692.47	30	10293(37)	3781.18
Zakharov(5)	30	5547(0)	848.01	30	5400(3)	969.54
F1.Sphere(2)	30	456(0)	85.08	30	456(0)	85.08
F2.Schwefel12(2)	30	448(0)	107.84	30	456(-2)	117.73
F3.HCRElliptic(2)	30	229(0)	39.21	30	229(0)	39.21
F4.Schwefel12Ns(2)	30	1299(0)	179.42	30	1109(15)	128.62
F5.Schwefel26(2)	30	17290(0)	5892.67	30	4309(75)	289.96
F6.Rosenbrock(2)	28	26143(0)	10203.05	30	12192(53)	3446.91
F7.Griewank(2)	28	5093(0)	1758.52	30	3696(27)	1163.52
F8.Ackley(2)	19	39890(0)	8510.64	26	22385(44)	10527.17
F9.Rastrigin(2)	30	2473(0)	922.8	30	1712(31)	316.78
F10.RastriginRot(2)	29	2724(0)	1145.1	30	1661(39)	314.39
F11.Weierstrass(2)	30	16782(0)	6048.9	30	7677(54)	1856.15
F12.Schwefel213(2)	30	2053(0)	598.1	30	1475(28)	341.31
F13.GriewRosen(2)	27	9321(0)	8889.6	30	3187(66)	2194.35
F14.Scaffer(2)	25	12475(0)	6386.04	30	5573(55)	1620.98
SUMMARY	**1469**	**6997.88(0.0)**	**2604.03**	**1486**	**4581.26(23.8)**	**1906.5**

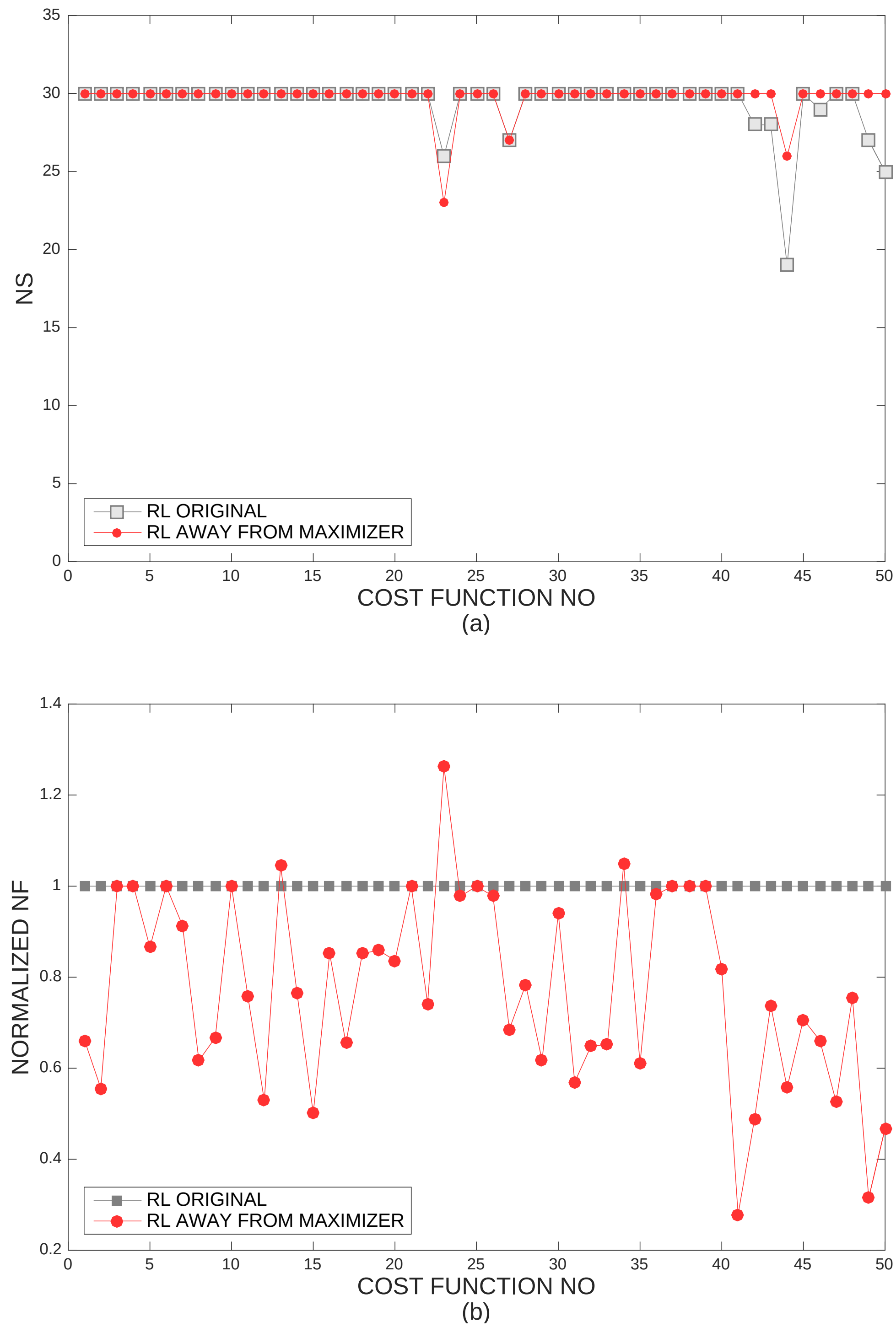

Figure 1 The number of successful runs (NS) and the normalized number of function evaluations (NF) for the original and improved RL algorithms are plotted in (a) and (b) respectively. The 50 cost functions are specified in **Part 3.5. Appendix**

Table 3 The numbers of successful runs (NS) and the average numbers of function evaluations (NF) for the DE, PS, JADE, and improved RL algorithms are listed. The same notations in **Part 3.5. Appendix**

***Table 2** are used.*

	DE			PS			JADE			RL		
CostFunctions	**NS**	**NF(%)**	**STD**	**NS**	**NF(%)**	**STD**	**NS**	**NF(%)**	**STD**	**NS**	**NF(%)**	**STD**
Alpine(5)	30	43417(0)	7873.31	15	14807(66)	6187.83	30	25977(40)	1582.6	30	15900(63)	3263.17
Bard(3)	30	3202(0)	354.26	30	4124(-22)	962.83	30	4846(-34)	607.75	30	2628(18)	301.61
Becker(2)	30	1944(0)	373.55	30	1592(18)	327.4	30	2031(-4)	438.52	30	624(68)	200.58
Branin(2)	30	867(0)	130.08	30	1435(-40)	311.39	30	1063(-18)	162.29	30	355(59)	62.79
Brown(2)	0	**(**)	**	30	13339(**)	1799.39	30	7032(**)	303.8	30	4091(**)	355.6
Camel3(2)	30	967(0)	142.13	30	1323(-27)	249.45	30	1153(-16)	173.27	30	485(50)	110.54
Camel6(2)	30	1489(0)	162.29	30	1589(-6)	285.35	30	1651(-10)	305.34	30	811(46)	121.57
Colville(4)	30	9792(0)	1182.6	30	9563(2)	4820.22	30	18544(-47)	3042.86	30	10315(-5)	3831.14
Cubic(2)	28	2859(0)	461.17	30	4328(-34)	1290.32	30	5216(-45)	963.59	30	4101(-30)	1106.46
Dejon4(5)	30	2677(0)	290.88	30	1240(54)	252.71	30	2117(21)	253.37	30	1347(50)	135.78
Dekker(2)	30	2452(0)	367.83	30	3231(-24)	257.88	30	2332(5)	366.63	30	1037(58)	143.62
Easom(2)	30	1271(0)	141.98	30	1533(-17)	343.5	30	1463(-13)	154.27	30	1035(19)	142
Exponential(5)	30	4953(0)	313.75	30	2880(42)	391.64	30	4190(15)	265.68	30	2240(55)	190.46
Freudenstein(2)	28	1836(0)	300.19	30	3033(-39)	855.08	29	2999(-39)	406.02	30	1608(12)	569.81
Gaussian(3)	29	6608(0)	1811.73	30	3540(46)	812.81	30	7662(-14)	1357.84	30	4756(28)	1070.41
Goldstein(2)	30	1321(0)	128.86	30	1965(-33)	274.07	30	1672(-21)	154.88	30	941(29)	129.39
Gulf(3)	30	3078(0)	564.86	30	4692(-34)	835.47	30	4514(-32)	614.05	30	2656(14)	786.25
Hartman3(3)	30	1904(0)	179.61	30	2372(-20)	300.51	30	2038(-7)	186.09	30	1392(27)	170.73
Hartman6(6)	14	12951(0)	2934.66	10	6708(48)	636.11	29	15501(-16)	6829.92	30	8784(32)	1270.51
Helical(3)	30	3834(0)	356.66	30	4370(-12)	321.79	30	6240(-39)	611.48	30	2548(34)	375.44
Hyperellipsoid(5)	30	7320(0)	330.52	30	5253(28)	520.43	30	6603(10)	285.85	30	3707(49)	554.56
Jennrich(2)	30	1852(0)	156.57	30	2364(-22)	341.74	30	2269(-18)	314.42	30	1707(8)	201.6
Kowalik(4)	7	39920(0)	26215.52	19	10661(73)	4057.35	22	16338(59)	3613.39	23	33750(15)	43398.17
Levy1(5)	30	7083(0)	324.92	30	5627(21)	682.25	30	6837(3)	315.66	30	4327(39)	577.11
Matyas(2)	30	865(0)	125.83	30	1173(-26)	263.73	30	1140(-24)	172.21	30	221(74)	59.17
Miele(4)	30	1261(0)	209.76	30	760(40)	228.94	30	1253(1)	282.13	30	3307(-62)	704.46
MultiGaussian(2)	24	1660(0)	233.54	28	1759(-6)	372.77	28	2690(-38)	384.84	27	2926(-43)	1163.11
Periodic(2)	20	4482(0)	1850.75	21	3930(12)	3272.35	28	4217(6)	1261.65	30	2059(54)	770.11
Powell(2)	0	**(**)	**	30	7620(**)	1104.21	30	6795(**)	1546.47	30	7093(**)	2730.21
PowellsQ(4)	30	4947(0)	299.39	30	6117(-19)	1019.91	30	6355(-22)	512.33	30	2571(48)	431.96
Schaffer2(2)	30	5472(0)	297.56	30	8685(-37)	449.09	30	7763(-30)	304.26	30	5587(-2)	268.5
Shekel5(4)	30	6955(0)	558.2	17	6400(8)	2448.51	30	8989(-23)	1599.38	30	5216(25)	1447.86
Shekel10(4)	30	6437(0)	493.03	21	6453(-0)	1381.55	30	7629(-16)	684.48	30	4896(24)	1137.87
Step(5)	30	4303(0)	370.91	30	2710(37)	590.35	30	3790(12)	320.94	30	2233(48)	349.71
Wood(4)	30	9792(0)	1182.6	30	9563(2)	4820.22	30	18544(-47)	3042.86	30	10293(-5)	3781.18
Zakharov(5)	30	8930(0)	415.35	30	6370(29)	624.31	30	10473(-15)	558.28	30	5400(40)	969.54
F1.Sphere(2)	30	1364(0)	137.91	30	2179(-37)	279.65	30	1593(-14)	205.6	30	456(67)	85.08
F2.Schwefel12(2)	30	1404(0)	131.77	30	2300(-39)	297.81	30	1925(-27)	172.84	30	456(68)	117.73
F3.HCRElliptic(2)	30	2120(0)	184.05	30	4515(-53)	431.93	30	3791(-44)	248.29	30	229(89)	39.21
F4.Schwefel12Ns(2)	30	1431(0)	125.92	30	2283(-37)	267.18	30	1975(-28)	162.9	30	1109(22)	128.62
F5.Schwefel26(2)	30	3037(0)	138.94	30	5960(-49)	454.49	30	4377(-31)	184.56	30	4309(-30)	289.96
F6.Rosenbrock(2)	24	3182(0)	687.37	30	4716(-33)	1595.8	30	6643(-52)	1690.77	30	12192(-74)	3446.91
F7.Griewank(2)	30	3767(0)	465.3	20	6544(-42)	2437.16	30	6144(-39)	905.86	30	3696(2)	1163.52
F8.Ackley(2)	13	9818(0)	3020.27	13	9898(-1)	3668.88	21	12560(-22)	2055.43	26	22385(-56)	10527.17
F9.Rastrigin(2)	30	2271(0)	192.17	27	2711(-16)	783.08	30	2737(-17)	277.46	30	1712(25)	316.78
F10.RastriginRot(2)	30	2563(0)	275.32	28	2757(-7)	554.89	30	3940(-35)	494.58	30	1661(35)	314.39
F11.Weierstrass(2)	30	10649(0)	2766.41	30	7203(32)	571.79	20	16748(-36)	1153.71	30	7677(28)	1856.15
F12.Schwefel213(2)	30	2871(0)	653.71	30	2816(2)	435.09	30	4273(-33)	1162.12	30	1475(49)	341.31
F13.GriewRosen(2)	30	1931(0)	553.35	26	1885(2)	1089.25	30	2356(-18)	898.45	30	3187(-39)	2194.35
F14.Scaffer(2)	29	5345(0)	791.05	13	5102(5)	1988.34	28	13673(-61)	3651.5	30	5573(-4)	1620.98
SUMMARY	**1356**	**5634.44(0.0)**	**1276.22**	**1368**	**4679.52(-3.5)**	**1170.98**	**1465**	**6253.20(-18.2)**	**944.87**	**1486**	**4581.26(23.3)**	**1906.5**

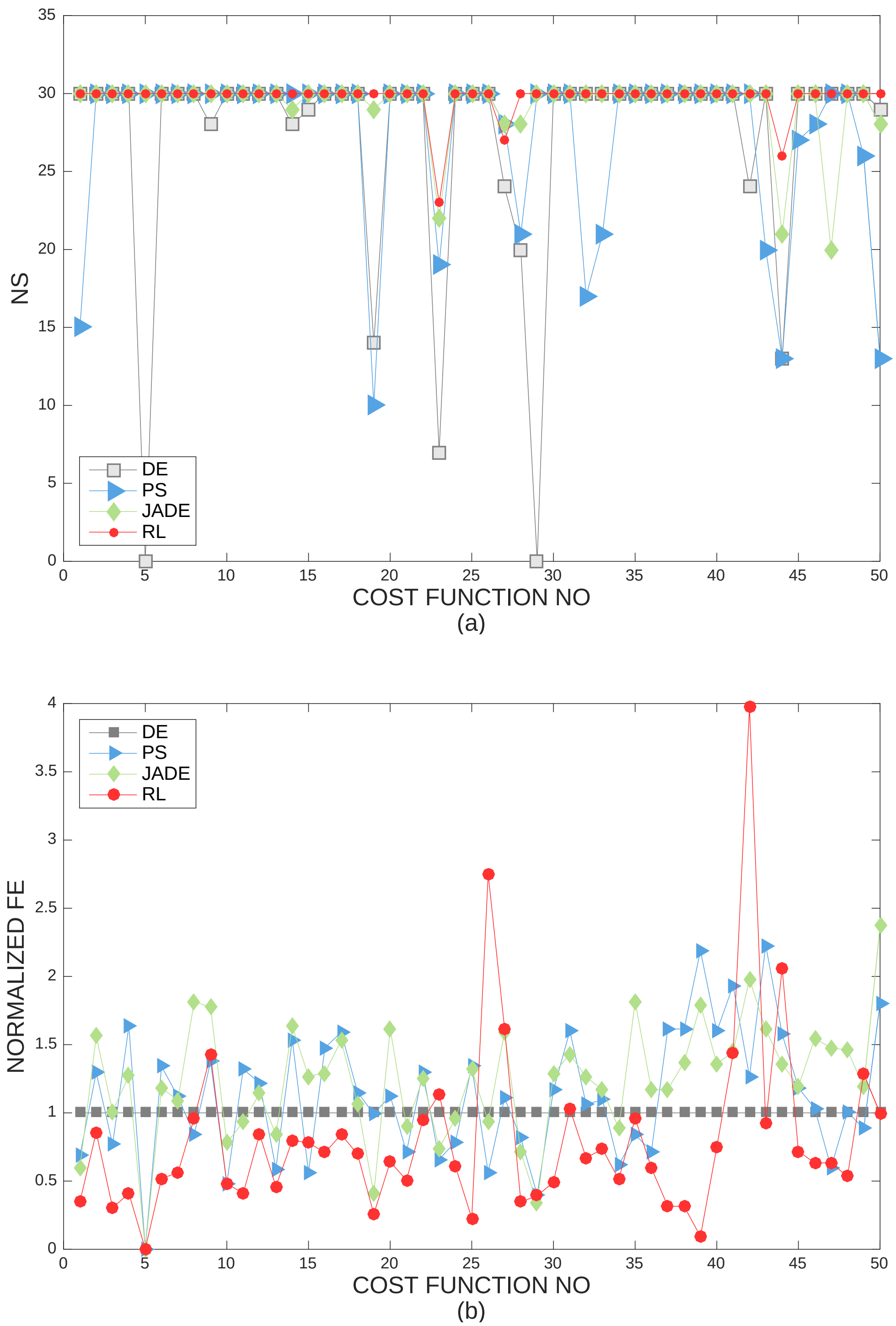

Figure 2 The number of successful runs (NS) and the normalized number of function evaluations (NF) for the DE, PS, JADE, and improved RL algorithms are plotted in (a) and (b) respectively. The 50 cost functions are specified in

Part 3.5. Appendix

Table 4 Wilcoxon signed-rank significance test results for the average number of function evaluations achieved by DE, PS, JADE, and RL algorithms over 30 runs for each function of Table 3. The (i, j)th entry is the number of cost functions that are significantly faster minimized by the algorithm on the ith row than the algorithm on the jth column. For instance, RL needs significantly a smaller number of function evaluations than JADE for 37 cost function.

	DE	PS	JADE	RL
DE	0	19	28	4
PS	11	0	16	4
JADE	6	14	0	2
RL	31	28	37	0

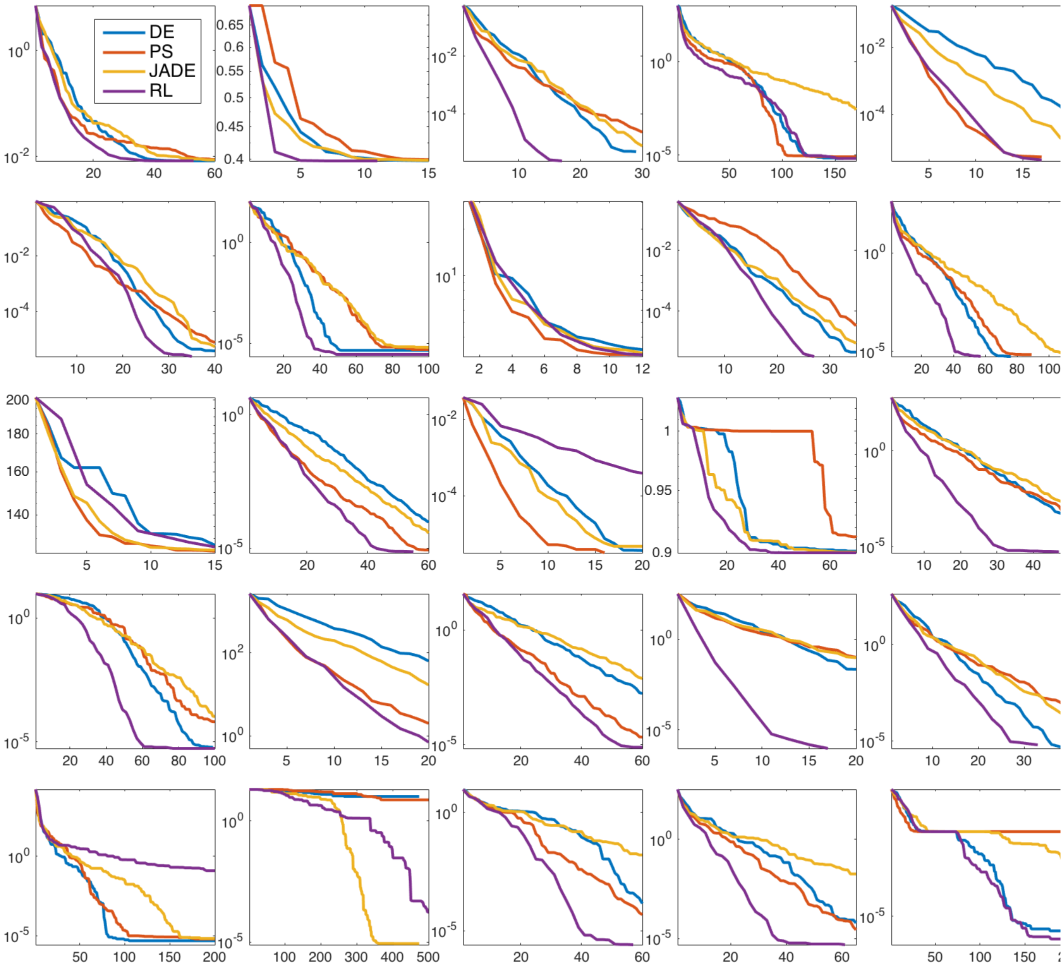

Figure 3 The medians of the cost function values over 30 runs are plotted as the number of generations increases along the horizontal axis. The even-numbered cost functions in **Part 3.5. Appendix**

Table 2 *are plotted. The base 10 logarithmic scale is used along the vertical axis for highlighting differences. If a global minimum is negative, then a constant is added to make it zero before plotting on the logarithmic scale. The first row plots the results for the cost functions 2, 4, …, 10 and the second row is for the cost functions 12, 14, …, 20, etc. The legend for all 25 plots is the same as specified in the top left subplot.*

Table 5 The numbers of successful runs (NS), the average numbers of function evaluations (NF), and the standard deviations of function evaluation counts STD are listed for the DE, PS, JADE, and the proposed RL algorithms for 10-dimensional cost functions.

	DE			PS			JADE			RL		
CostFunctions	**NS**	**NF(%)**	**STD**	**NS**	**NF(%)**	**STD**	**NS**	**NF(%)**	**STD**	**NS**	**NF(%)**	**STD**
Alpine(10)	1	490400(0)	0	1	26400(95)	0	30	82380(83)	3052.35	30	40107(92)	5566.95
Dejon4(10)	30	16013(0)	690.69	30	4673(71)	583.65	30	6887(57)	542.49	30	4627(71)	1164.69
Exponential(10)	30	24773(0)	890.92	30	8760(65)	817.73	30	11100(55)	471.97	30	12493(50)	2274.74
Hyperellipsoid(10)	30	37360(0)	760.04	30	16073(57)	1386.12	30	19793(47)	518.57	30	23613(37)	2392.51
Levy1(10)	30	33880(0)	1055.17	27	17311(49)	3436.61	30	18533(45)	709.22	30	20253(40)	2092.31
Step(10)	30	22060(0)	1006.39	22	13355(39)	5567.57	30	13000(41)	603.44	30	11100(50)	2272.66
Zakharov(10)	30	61967(0)	2178.32	30	22593(64)	2457.63	30	37967(39)	1995.92	30	40160(35)	4220.56
F1.Sphere(10)	30	48080(0)	991.83	30	21007(56)	1128.3	30	26993(44)	760.19	30	42666(11)	2916.91
F2.Schwefel12(10)	30	79827(0)	1764.58	30	28860(64)	2603.53	30	43307(46)	1684.6	30	70626(12)	7095.16
F3.HCRElliptic(10)	30	164693(0)	3893.67	0	**(**)	**	30	52427(68)	1030.21	30	143867(13)	22848.93
F4.Schwefel12Ns(10)	30	88033(0)	2176.41	5	39600(55)	8856.64	30	46773(47)	2070.97	30	110787(-21)	15487.92
F5.Schwefel26(10)	30	253733(0)	3894.23	0	**(**)	**	30	75773(70)	2286.83	30	339235(-25)	75086.23
F6.Rosenbrock(10)	30	132680(0)	5326.21	0	**(**)	**	17	92153(31)	8690.95	14	243171(-45)	63569.07
SUMMARY	**361**	**111807.6(0)**	**2052.4**	**235.0**	**19863.2(61.5)**	**2982.0**	**377.0**	**40545.1(51.8)**	**1878.3**	**374.0**	**84823.5(24.6)**	**15922.2**

Table 6 Wilcoxon signed-rank significance test results for the average number of function evaluations achieved by DE, PS, JADE, and RL algorithms over the cost functions specified in Table 5. The notation of Table 4 is used here.

	DE	**PS**	**JADE**	**RL**
DE	0	0	0	2
PS	6	0	6	5
JADE	11	0	0	9
RL	9	0	3	0

Table 7 Mean of the best (minimum) function values and their standard deviations for DE, PS, JADE, and RL algorithms over 10-dimensional cost functions. Each of 30 runs is terminated when the function evaluation count reached to 99800 for all algorithms. The function values that are less than 1E-4 are typed in bold.

	DE		PS		JADE		RL	
CostFunctions	**FBEST**	**STD(FBEST)**	**FBEST**	**STD(FBEST)**	**FBEST**	**STD(FBEST)**	**FBEST**	**STD(FBEST)**
Alpine(10)	4.69E-03	6.11E-04	1.43E-01	1.96E-01	**2.32E-05**	4.12E-06	**1.21E-11**	3.53E-11
Dejon4(10)	**2.62E-34**	3.39E-34	**6.46E-65**	1.71E-64	**6.50E-48**	1.52E-47	**5.62E-22**	2.55E-21
Exponential(10)	**-1.00E+00**	0.00E+00	**-1.00E+00**	8.25E-17	**-1.00E+00**	0.00E+00	**-1.00E+00**	0.00E+00
Hyperellipsoid(10)	**1.41E-17**	8.77E-18	**1.57E-35**	3.29E-35	**4.20E-25**	4.31E-25	**1.80E-19**	2.08E-19
Levy1(10)	**3.06E-18**	1.92E-18	3.11E-02	9.49E-02	**1.38E-24**	1.56E-24	**1.25E-19**	2.50E-19
Step(10)	**0.00E+00**	0.00E+00	2.67E-01	4.50E-01	**0.00E+00**	0.00E+00	**0.00E+00**	0.00E+00
Zakharov(10)	**2.36E-10**	1.41E-10	**2.73E-33**	5.10E-33	**3.10E-25**	1.21E-24	**1.31E-13**	1.92E-13
F1.Sphere(10)	**1.68E-15**	8.62E-16	**0.00E+00**	0.00E+00	**3.39E-23**	4.53E-23	**3.32E-16**	4.60E-16
F2.Schwefel12(10)	**6.21E-08**	3.66E-08	**4.25E-29**	6.10E-29	**3.84E-24**	5.98E-24	**1.49E-08**	3.27E-08
F3.HCRElliptic(10)	7.57E-01	4.71E-01	2.72E+04	3.39E+04	**1.41E-19**	1.54E-19	5.90E+00	2.71E+01
F4.Schwefel12Ns(10)	**5.86E-07**	3.12E-07	1.19E+00	2.16E+00	**2.29E-21**	5.50E-21	7.74E-04	2.33E-03
F5.Schwefel26(10)	1.78E+00	4.10E-01	5.58E+02	3.77E+02	**6.09E-08**	4.44E-08	1.84E+01	2.44E+01
F6.Rosenbrock(10)	1.12E-01	9.65E-02	4.90E+02	1.56E+03	2.33E+00	2.72E+00	2.54E+01	5.51E+01
F7.Griewank(10)	4.18E-01	6.36E-02	9.66E-01	8.03E-01	7.13E-02	2.57E-02	9.67E-02	4.59E-02
F8.Ackley(10)	2.03E+01	8.20E-02	2.02E+01	1.15E-01	2.03E+01	9.78E-02	2.03E+01	9.73E-02
F9.Rastrigin(10)	2.22E+01	3.49E+00	2.06E+01	7.73E+00	**1.15E-10**	7.52E-11	3.99E+00	1.52E+00
F10.RastriginRot(10)	2.90E+01	4.58E+00	2.15E+01	8.37E+00	7.70E+00	1.59E+00	1.14E+01	4.14E+00
F11.Weierstrass(10)	8.52E+00	5.09E-01	5.45E+00	1.67E+00	5.86E+00	6.57E-01	2.40E+00	1.05E+00
F12.Schwefel213(10)	1.49E+04	4.51E+03	6.06E+02	1.25E+03	3.30E+02	1.52E+02	1.28E+02	3.83E+02
F13.GriewRosen(10)	2.20E+00	2.72E-01	1.05E+00	4.15E-01	4.83E-01	7.11E-02	5.82E-01	1.69E-01
F14.Scaffer(10)	3.87E+00	1.49E-01	3.21E+00	3.57E-01	3.26E+00	1.52E-01	3.00E+00	2.06E-01

Table 8 Wilcoxon signed-rank significance test results for best function values achieved after performing 99800 function evaluations for minimizing each of the cost functions by DE, PS, JADE, and RL algorithms over the cost functions specified in Table 5. The notation of Table 4 is used here.

	DE	**PS**	**JADE**	**RL**
DE	0	7	1	4
PS	12	0	7	7
JADE	17	10	0	15
RL	13	13	4	0

SECTION 4.

Proposed New Undergraduate Course

"MTMS 448 - Introduction to Maritime Cybersecurity"

Part 4.1. Background and Objectives:

Today's computer systems handle important transactions in many different services provided by private or governmental agencies. Computer systems of banks allow users to make online payments, transfer money between banks, and monitor suspicious activities. Hospitals also use them to gather real-time data from multiple sensors attached to patients, monitor their conditions, and take immediate actions when emergencies arise. Students register for courses and track their grades by using the online services provided by universities. Ships decide on their routes based on data from multiple sources.

Most of the above systems need to connect to a network for either providing the essential services or obtaining critical data that they use in making decisions. When a computer system is connected to a network, the system becomes available to its administrators and users but also malicious attackers. Attackers may steal a large sum of money from banks, interrupt the treatment of some patients in hospitals, change grades of students in universities, or change the route of a ship. For instance, the world's biggest shipping company A.P. Moller Maersk's computers were infected by malware in June 2017 and the estimated cost for this attack was as much as $300 million.

Recent large-scale cybersecurity attacks to shipping companies and ports have increased the need for well-educated cybersecurity professionals in this field. This course aims to produce these professionals by teaching the principles of cybersecurity and its application to maritime. The students will learn how to identify vulnerabilities of a given system, prioritize different threats, and place resources to protect the system against the most harmful ones. They will also learn the types of threats in maritime and necessary countermeasures against them. In addition to putting economically sound best defense systems in place, the students will learn how to detect an ongoing attack, to stop it immediately, and mitigate the harm caused by the attack.

Part 4.2. Course Outline

There are two major components in this course. The first part presents the principles of cybersecurity including the methods of identifying weaknesses, detecting attacks, defending systems, and reducing the harm. The second part describes specific threats and their countermeasures from the maritime perspective.

The first part defines the cybersecurity terms of confidentiality, integrity, and availability and the tools for protecting these three aspects of a given asset. Identification, authentication, and access control methods are the concepts in protecting confidentiality. Cryptography constitutes the main method of protecting the integrity of data. Students will also learn how to implement basic encryption and decryption algorithms in the programming language Python. Fundamentals of computer networks finalize the first part as this knowledge will help the students understand possible methods of intrusion into a network device, and ways of detecting and preventing the intrusion.

The second part focuses on cybersecurity in maritime. It starts with the importance of cybersecurity in maritime, determining vulnerabilities of ships and ports, and mitigating damages against most frequently occurring attacks such as ransomware attacks. Then it describes maritime access control technologies including on-land intrusion detection systems based on infrared sensors and video. Students will learn authentication methods based on multiple biometric features. They will have a good knowledge of GPS (Global Positioning System) and AIS (Automatic Identification System) and jamming and spoofing of GPS signal attacks against these systems.

Part 4.3. Syllabus

Texas Southern University
Department of Maritime Transportation Management and Security
Fall 2019

Syllabus for **MTMS 448 – Introduction to Maritime Cybersecurity (3 Credit Hours)**

Instructor: TBD
Office Location: TBD
Office Phone: TBD

Course Description:

This course introduces the basic concepts of maritime cybersecurity. In this class, confidentiality, integrity, and availability of maritime assets are defined. The methods of protecting these three qualities including authentication, encryption, and intrusion detection and prevention are presented. Computer network fundamentals are taught for understanding these methods. Maritime-specific security risks and countermeasures are emphasized.

Prerequisite:

None

Class Time and Place:

Monday 5:30 p.m. – 8:00 p.m. at Technology Building - 217

Office hours:

TBD

Required Textbook:

Security in Computing (5th Edition) by Charles P. Pfleeger, Shari Lawrence Pfleeger, and Jonathan Margulies; ISBN: 978-0134085043

Handouts will also be given in some lectures.

Useful Textbooks:

Network Defense and Countermeasures: Principles and Practices (3rd Edition), by William (Chuck) Easttom; ISBN: 9780134893099

Practical Guide to Computer Forensics Investigations, by Darren R. Hayes; ISBN: 9780132756150

Course Objectives:

The students will learn the definitions of confidentiality, integrity, and availability and the tools for protecting these three aspects of an asset. They will also learn the identification and authentication processes as well as access control methods. Students will have hands-on experience by implementing some encryption and decryption algorithms in the programming language Python. They will know about intrusion detection and prevention after learning the fundamentals of computer networks. Once the cybersecurity principles are covered, their attention will be focused on the importance of cybersecurity in the maritime, determination of vulnerabilities of ships and ports, and then mitigation of damages against the most frequently occurring attacks such as ransomware attacks. Students will complete this class by learning GPS (Global Positioning System) and AIS (Automatic Identification System), jamming, and spoofing GPS signal attacks in maritime systems. A student who completes this class will have a good understanding of basic cybersecurity concepts and the tools for preventing and detecting cyberattacks and mitigating their harm in maritime applications.

Course Requirements:

Instead of classical quizzes, the lecturer may ask questions about important concepts and award 1 point to the students who provide correct answers. This approach encourages students to attend classes and to understand the topics in the class. Students are responsible for doing their homework and project assignments and return them on time. Students are allowed to work in groups for doing their project assignments. In this case, each group member must be familiar with every step of the project. They are also required to take their midterm and final exams.

There are no make-ups for missed homework, project assignments, or exams except a significant medical reason (Doctor's statement is required)

Grading Policy:

30% Homework and projects
30% Midterm
40% Final Exam
100% Total

Good attendance is encouraged to have the opportunity of answering some questions during the classes and obtaining extra credit. A student may gain extra points up to 5 points this way until the end of the semester. These points are added to the total after the total is determined as above.

Missing an exam is not acceptable except significant medical reasons (a doctor's statement is required)

Homework must be returned on the due date. After the due date, returned homework will not be graded since homework solutions will already have been available through the Blackboard.

Course Schedule:

Week	Content	Textbook
1, 2	Definition of Vulnerability, Confidentiality, Integrity, Availability, Threat, and Control	Chapter 1
3	Authentication, Access Control, Certificates, and Keys	Chapter 2

4, 5	Cryptography and Protecting Data Integrity, Symmetric and asymmetric cryptography, Multiple Ciphers including Vignere cipher and Advanced encryption systems (AES)	Chapter 2, Handouts
6	Concise Introduction to Python Programming, Implementation of Some Selected Ciphers Such As XOR cipher and ROT 13 in Python	Handouts
7	Programs and Programming Related Weaknesses and Countermeasures	Chapters 3, 4
8	**Review and Midterm Examination**	NA
9	Principles of Communication Network and Internet Security	Chapter 6
10	Importance of Cyber Security in Maritime Systems	Handouts
11	Safety and Security in Maritime Transportation Systems	Handouts
12	Maritime Access Control Technologies	Handouts
13	Satellites, GPS (Global Positioning System)	Handouts
14	AIS (Automatic Identification System)	Handouts
15	Jamming and Spoofing	Handouts
16	**Guest lecture and Final Project**	NA

Disability statement:

It is the policy of Texas Southern University to provide reasonable and appropriate accommodations for qualified individuals who are students with documented disabilities. This university will adhere to all applicable Federal and State laws, regulations, and guidelines with respect to providing reasonable accommodations as required to afford the equal educational opportunity. If you have or believe you have, a disability & would benefit from accommodations you may wish to self-identify by contacting the ADA/Section 504 Coordinator. Please ensure that this is done on time.

Dropping The Course Or Withdrawing From The University:

Students are responsible for initiating the action required to drop the course or withdraw from the university.

SECTION 4.

Collaborations with Other Institutions

Part 4.1. Collaborations with DHS COE partners

We built a strong collaboration with the colleagues Dr. Susanne Wetzel and Dr. Beth DeFares at the Stevens Institute of Technology. They made valuable contributions in deciding and building the content of the new course **Introduction to Maritime Cyber Security.** In particular, Dr. Wetzel was ready to help anytime, she gave me very helpful feedback when I shared the topics of the new course, and she was very generous to share the similar courses that she teaches at her institution.

Part 4.2. Collaborations with Other Experts

We communicated with Dr. Meltem Sonmez Turan who is a cybersecurity researcher in the Cryptographic Technology Group at NIST (National Institute of Standards and Technology. She also provided valuable guidance on the most important current problems and existing solutions to these problems. She advised us to focus on ransom and phishing attack prevention as she stressed that a very large number of total attacks rely on cheating the target, getting credential information from him/her, and accessing the target system without any problem thereafter. Her contact info: meltem.turan@nist.gov, (301) 975-4391

We also closely worked with Abayomi Ajofoyinbo(1), Nuri Yilmazer (2), Tugcan Celebi (3), and Selahattin Ozcelik (4) whose workplace and contact information are

(1) Department of Engineering, College of Science, Engineering and Technology, Texas Southern University, 3100 Cleburne Street, Houston TX USA 77004 (email: ismet.sahin@tsu.edu and abayomi.ajofoyinbo@tsu.edu)
(2) Department of Electrical Engineering and Computer Science, Texas A&M University, Kingsville, TX USA 78363 (email: nuri.yilmazer@tamuk.edu)
(3) Department of Control and Automation Engineering, Yildiz Technical University, Istanbul, TURKEY 34220 (email: f6716016@std.yildiz.edu.tr)

(4) Department of Mechanical and Industrial Engineering, Texas A&M University, Kingsville, TX USA 78363 (email: selahattin.ozcelik@tamuk.edu)

They were very helpful in providing different ideas, performing a large number of simulations, and writing the manuscript for the new RL optimization algorithm.

SECTION 5.

Published Journal and Conference Articles and Presentations

We finished writing a manuscript that presents the new machine learning methods for automatically detecting malicious web site addresses to prevent cyber-attacks in maritime information systems. In the manuscript, we present a rigorous justification of how the new machine learning algorithm EWKNN performs better than the others in general. The paper will be submitted to a journal in a near future. The second paper in Part 4.1. has the details of the new RL algorithm and its results. In future work, we are going to use this algorithm in neural networks to increase their accuracy levels by finding a better optimum point out of many optimum points.

Part 5.1. Published Journal Articles:

- Yu Zhang, Vidhi Chandra, Erick Riquelme Sanchez, Prasanta Dutta, Pompeyo Quesada, Amanda Rakoski, Michelle Zoltan, Nivedita Arora, Seyda Baydogan, William Horne, Jared Burks, Hanwen Xu, S. Perwez Hussain, Huamin Wang, Sonal Gupta, Anirban Maitra, Jennifer Bailey, Seyed Javad Moghaddam, Sulagna Banerjee**,** **Ismet Sahin**, Pratip Bhattacharya, and Florencia McAllister, "Interleukin 17 induced-neutrophil extracellular traps mediate resistance to checkpoint blockade in pancreatic cancer" (**Accepted** on July 6, 2020 by) Journal of Experimental Medicine
- **Sahin, Ismet,** and Yilmazer, Nuri and Celebi, Tugcan and Ozcelik, Selahattin and Ajofoyinbo, Abayomi, "Stepping away from maximizers of concave quadratics in random line search," *Evolutionary Intelligence*, Mar. 16, 2020 (DOI: https://doi.org/10.1007/s12065-020-00380-1)
- De Jesus-Acosta, Ana and Sugar, Elizabeth A. and O'Dwyer, Peter J. and Ramanathan, Ramesh K. and Von Hoff, Daniel D. and Rasheed, Zeshaan and Zheng, Lei and Begum, Asma and Anders, Robert and Maitra, Anirban and McAllister, Florencia and Rajeshkumar, N. V. and Yabuuchi, Shinichi and de Wilde, Roeland F. and Batukbhai, Bhavina and **Sahin, Ismet** and Laheru, Daniel A., "Phase 2 study of vismodegib, a hedgehog inhibitor, combined with gemcitabine and nab-paclitaxel in patients with untreated metastatic pancreatic adenocarcinoma," *British Journal of Cancer*, vol. 122, no. 4, pp. 498—505, Feb. 18, 2020
- Erick Riquelme, Yu Zhang, Liangliang Zhang, Maria Montiel, Michelle Zoltan, Wenli Dong, Pompeyo Quesada, **Ismet Sahin**, Vidhi Chandra, Anthony San Lucas, Paul Scheet, Hanwen Xu, Samir M. Hanash, Lei Feng, Jared K. Burks, Kim-Anh Do, Christine B. Peterson, Deborah Nejman, Ching-Wei D. Tzeng, Michael P. Kim, Cynthia L. Sears, Nadim Ajami, Joseph Petrosino, Laura D. Wood, Anirban Maitra, Ravid Straussman, Matthew Katz, James Robert White, Robert Jenq, Jennifer Wargo, and Florencia McAllister, "Tumor Microbiome Diversity and CompositionInfluence Pancreatic Cancer Outcomes," Cell, vol. 178, pp. 795–806, Aug. 8, 2019
- **Ismet Sahin**, Yu Zhang, Florencia McAllister, "Tumor Spheres Quantification with

Smoothed Euclidean Distance Transform," Journal of Molecular Imaging and Dynamics, vol.8, no.1, pp. 143, 2018. doi:10.4172/2155-9937.1000

- Zhang Y., Zoltan M., Riquelme E., Xu H., **Sahin I.,** Castro-Pando S., Montiel MF., Chang K., Jiang Z., Ling J., Gupta S., Horne W., Pruski M., Wang H., Sun SC., Lozano G., Chiao P., Maitra A., Leach SD., Kolls JK., Vilar E., Wang TC., Bailey JM., McAllister F., "Immune Cell Production of Interleukin 17 Induces Stem Cell Features of Pancreatic Intraepithelial Neoplasia Cells," Gastroenterology, vol. 155, no: 1, pp. 210-223, Mar 29 2018. DOI: 10.1053/j.gastro.2018.03.041

Part 5.2. Oral and Poster Presentations

- Nuri Yilmazer and Ismet Sahin, "Accurate Beamforming By Using Population-Based Optimization Methods," INFORMS 2017, Houston, TX. October 2017
- Abayomi Ajofoyinbo and Ismet Sahin, "Electrical Power Grid Optimization Using Semi-Markov Decision Process," INFORMS 2017, Houston, TX. October 2017
- **Ismet Sahin** and Nuri Yilmazer, "Frequency Domain Time Delay Estimation with Optimization over Randomly Selected Lines," College Station, TX, GOC 2017 (Global Optimization Conference). March 2017

SECTION 6.

Supervised Students

Dr. Sahin supervised the students Mr. **Dayo Fade**, Mr. **Alex Romero**, and Mr. **Marco Collazo** at different intervals. They learned how to use Matlab/Python for performing real simulations using machine learning algorithms for cybersecurity applications. Mr. Marco Collazo was able to implement a Perceptron algorithm and use it for automatic detection of malicious web sites. Even though the Perceptron algorithm is a relatively simple method, its accuracy rates were about 82%. The newly proposed EWKNN achieves accuracy rates of about 94%.

Mr. **Alex Romero** did find a **maritime cybersecurity** job after his graduation. He was kind to send Dr. Sahin the following email:

“Hello Dr. Sahin,

I would like to thank you for all your guidance and help. I stayed within the Cyber Security field and have been working for Tokio Marine HCC. Good thing is I am allowed to learn some python scripting.

V/R,

Alex Romero”

SECTION 7.

Other Cyber Security-Related Activities

Dr. Sahin taught the course "ECE 439 Applied Cyber Security" in Fall 2018 and again in Fall 2019 in the Department of Engineering. During this class, Dr. Sahin focused on having the students first-hand experience by helping them write Python code on cybersecurity. He provided multiple handouts in which various cybersecurity-related algorithms were implemented in Python. In the following, I will include only three of these algorithms among many others that used studied in the classes. The names of these ciphering algorithm are Tiny Encryption Cipher (tea cipher), Reverse Cipher, and Ceaser Cipher:

```
from ctypes import *

def tea_cipher( V, K ):

    # L is v0 and R is v1 (V contains our 64 bit block)

    v0 = c_uint32(V[0])

    v1 = c_uint32(V[1])


    # sum represents the current key (subkey)

    sum = c_uint32(0)

    delta = 0x9E3779B9


    # number of rounds

    nrounds = 32


    while( nrounds > 0 ):

        #FIRST BLOCK

        # the current subkey
```

```
sum = sum.value + delta

# points before xor
upper = (v1.value << 4) + K[0]
middle = v1.value + sum.value
lower = (v1.value >> 5) + K[1]

z = upper ^ middle ^ lower

v0.value = v0.value + z.value
#FIRST BLOCK ENDS

#SECOND BLOCK
# points before xor
upper = (v0.value << 4) + K[0]
middle = v0.value + sum.value
lower = (v0.value >> 5) + K[1]

z = upper ^ middle ^ lower

v1.value = v1.value + z.value
#SECOND BLOCK ENDS
```

```
        # update the loop counter
        nrounds = nrounds - 1

    w = [v0.value, v1.value]
    return w

k = [32, 5, 111, 7]
v = [82344, 13435242]
C = tea_cipher( v, k )
print(C)


def reverse_cipher( P ):
    #create an empty list and append chars
    C = []

    # size of the string P
    L = len(P)

    # start appending chars from P in reverse order
    for k in range(L-1, -1, -1):
        C.append(P[k])

    return C
```

```
def obtain_alphabet_in_3_different_ways():

    A = 'A a B b C c D d E e F f G g H h I i J j K k L l M m N n O o P p Q q R r S s T t U u V v
W w X x Y y Z z'

    N = len(A)



    Y = []

    k = 0

    while k < N:

        Y.append( A[k] )

        k = k + 4

    print(Y)



    Z = []

    for k in range(0, N, 4):

        Z.append( A[k] )

    print(Z)



    # use ord('A') to find A's ascii value

    # empty space character's ascii code is 32

    # lower letters ascii values are larger than 97

    W = []

    for c in A:
```

```
        asciival = ord(c)

        if asciival > 64 and asciival < 91:

            W.append(c)

    print(W)




def obtain_alphabet():

    A = 'A a B b C c D d E e F f G g H h I i J j K k L l M m N n O o P p Q q R r S s T t U u V v W w X x Y y Z z'

    Z = []

    for k in range(0, len(A), 4):

        Z.append( A[k] )

    return Z




def ceaser_cipher(P, K):

    C = []

    for c in P:

        asciival = ord(c)

        cipherchar = chr( asciival + K )

        C.append( cipherchar )

    return C
```

SECTION 7.

Conclusion

As the PI for Secure and Efficient Maritime Data Storage and Retrieval for this research and educational grant, I had the opportunity of making the following contributions (i) Improving the use of different machine learning algorithms for automatic recognition of dangerous actors in the cyberspace and preventing random and phishing attacks originating from them. To this end, I proposed a new machine learning algorithm called EWKNN which achieves very promising results compared to other KNN variants in literature. I completed writing the manuscript for this method and obtained numerous results showing its effectiveness. I also supervised multiple undergraduate students in this direction and they learned how to try new ideas by implementing their ideas in Python or Matlab programming languages. One of them was very inspired by this research experience and now he (Alex Romero) is working as a maritime cybersecurity engineer in the company called Tokio Marine HCC.

(ii) I had the opportunity to improve the effectiveness of an optimization algorithm called Random Lines (RL). I am planning to use RL for improving the classification accuracies of neural networks for improving the effectiveness of detecting malicious web sites that are used in random and phishing attacks. I and my collaborators worked on this algorithm meticulously to provide its details and to show that it achieves great results over 50 different types of objective functions and then published these results in a journal.

(iii) I had the opportunity of constructing a new course named "**MTMS 448 – Introduction to Maritime Cybersecurity".** This course will be taught at Texas Southern University to provide highly knowledgeable and skilled students in the field of maritime cybersecurity. Its content has become much better after we exchanged ideas regularly with our colleagues at the Stevens Institute of Technology.