MarTREC
Maritime Transportation Research & Education Center

BIL MarTREC Tier 1 UTC Project Request Form
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Submission Date: 05/15/2024
Lead Recipient/Grant Number: University of Arkansas / 69A3552348331
Principal Investigator Institution: Jackson State University
Center Name: Maritime Transportation Research and Education Center
USDOT Research Priority: Preserving the Existing Transportation System
Primary USDOT Strategic Goal (*select drop down*): Economic Strength and Global Competitiveness
Principal Investigator(s) with ORCID(s) and Contact Information: *Tor A. Kwembe* *ORCID: https://orcid.org/0000-0003-4720-2323; Email: tor.a.kwembe@jsums.edu*
Project Partners: *Provide full name of any partner organization(s) who will actively engage in the project*: n/a
Project Type (*select drop down*): Applied Research
Project Research Topic Type (*select drop down*): Maritime and Multimodal Supply Chain Management
Transportation Modes Involved (*check all that apply*): ☒Waterway ☐Road ☐Rail ☐Pipeline ☐Other
Research Project Funding: Budget Amounts & Sources (USDOT + Matching funds = Total Cost): MarTREC $55,000 + JSU $27,500 = $82,500.
Project Start and End Dates (Format month/day/year to month/day/year): 08/01/2024 to 08/30/2025
Project Title: An automated training model for selecting maritime traffic monitoring and tracking model types using AIS data with missing information
Project Abstract (Brief Description): This project will utilize Automatic Identification System (AIS) datasets to design scalable Automated Maritime Traffic Monitoring and Analysis (AMTMA) applications and tools and work with two Computational data enabled science and engineering (CDS&E) Ph.D. students to produce two dissertations in this direction. Critical applications such as the detection of anomalies, offshore and onshore attacks and data intrusions, require fast mechanisms for Artificial Intelligence (AI) analysis of thousands of events per second, as well as efficient techniques for the analysis of massive historical AIS data with missing information. There have been major developments of Big Data Analysis Frameworks for analyzing the AIS historical data, but their applications and scalable analysis techniques to the AMTMA domain remains poorly understood and difficult to benchmark due to the frequency of missing information in the often collected AIS datasets. This project introduces a Least-squares regression model with missing data and a Principal Component model for sparse functional data using AIS data that will aid in monitoring maritime traffic and directly assist in averting accidents, tracking vessels, and support in avoidance of dangerous environments. The elements of a cleaned AIS dataset with missing information are often presented as curves (trajectories) rather than single points. Functional principal components can be used to describe models of variation of such curves. If one has complete measurements for each vessel trajectory or, as is more common, one has the dataset in a spreadsheet format collected at the same time points (time stamps) for all trajectories, then many standard data analytics techniques may be applied. However, vessel trajectory data as appeared in the AIS dataset is collected at irregular and sparse set of time stamps which can differ widely across individual vessels. This project will present a technique for handling this more difficult case using a reduced rank mixed effects framework. This project also explores a Least-square regression model with missing data to develop a Regression Learner app to automatically train a selection of different models on the AIS data. An automated training model will be developed to quickly try a selection of model types, and then explore promising models interactively.
USDOT Priorities: By developing an AI systems for tracking and monitoring global maritime traffic, the proposed project supports the following objectives of the US DOT priorities:

Improving mobility of people and goods; Reducing bottleneck congestion; Promoting vessel safety; Improving the durability and extending the life of transportation infrastructure; Reducing transportation cybersecurity risks.
The project also support the following RD&T strategic goal:
* Safety: Make our maritime transportation system safer for all shipments and advance a future where maritime transportation-related serious injuries and fatalities are eliminated.

Outputs (results of the work performed):
The project will result in the development of an automated Regression Learner App model for selecting ideal models for monitoring and tracking maritime traffic using the AIS data with missing information from a pack of different models.

Outcomes/Impacts:
The proposed projects will advance the understating of the AMTMA communities on the open problems. The outcomes of the project have direct impact and application in the AMTMA domain, including benefits for large shipping line operators and maritime traffic monitoring technology vendors. The techniques developed within the span of the project as well as their applications to AIS and freeware data analytic problems would also be highly beneficial to other domains where similar data analysis problems arise, including the Online monitoring of road traffic devices, the Online extraction of knowledge from big data associated to smart cities scenarios, the processing of the massive data generated by the Internet of Things with trillions of devices connected to the Internet, and many other application domains. Being the Big Data Analyst a fast-growing worldwide market, the development of analysis techniques, technologies will directly benefit the research on AMTMA. The state of Mississippi, being a coastal state will benefit from the technologies that will result from the AMTMA research and the outcome of the projects we have proposed to carry out.
Direct Educational Impact:
The project will engage two CDS&E Ph.D. students with excellent academic records in a yearlong research activity in the use of AIS datasets with missing information to model maritime traffic tracking and monitoring. Consequently, there will be two Ph.D. dissertations resulting from the outcomes of the project. The program Graduate Assistants will acquire broad data science and big data analytics skills geared towards effective applications of the CDS&E methods in novel maritime traffic modeling and analysis. There will be three scholarly articles resulting from each objective of the project. The finding may also result in the development of a new course and curriculum revision to improve the CDS&E Ph.D. program curriculum.

Technology Transfer Activities: A patent might be sought for the developed app. The techniques and methodology of the app will be shared through publications, presented at local and national conferences and summarized in the final report. The developed methods and algorithms will be transferred through the resulting dissertations of the participating CDS&E Ph.D. Students. The outcomes will also be published in high quality journals such as TRR, Zenodo, MarTREC approved journals, and the proceedings of the International Conferences on Computational Science and Computational Intelligence (CSCI).

Final Research Report: Upon completion of the project, a URL link to final report will be provided

Project Deliverables: ☒ PI agrees to submit all deliverables within 4 weeks after the project end date.

Data Management Plan (DMP): ☒ PI has reviewed and agrees to adhere to MarTREC DMP. Proposed project DMP must be attached to the submission email along with this form.

Center Director Approval Signature and Date: Heather Nachtmann 07.15.24