

High Performance Computing

ARTIFICIAL INTELLIGENCE MODELING FOR MARITIME OPERATION EFFICIENCY AND TRAFFIC SAFETY ENHANCEMENT

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### Agenda

- Brief Introduction of IHPC
- AI applications in maritime and challenges
- Examples of AI applications
  - Port operation efficiency
  - Traffic safety



<u>A\*STAR</u>: Agency of Science, Technology and Research

# **Co-innovation through Deep Multidisciplinary Modelling, Simulation and Knowledge-driven Al**





# **AI Applications in Maritime**

CREATING GROWTH, ENHANCING LIVES



Z. H. Munim, et al, "Big data and artificial intelligence in the maritime industry: a bibliometric review and future research directions," Copyright @ IHPC 2020. All rights reserved.



# **Challenges of Applying AI in Maritime**











Data availability,	Data <b>privacy</b> and	Computing is not	Trustworthy &	Lack of clarity of
data scarcity and	data <b>security</b>	advanced for handling	explainable Al	relevant
data <b>quality</b> in	problem	large-scale data,	Systems	regulations, like Al
maritime		especially for		in autonomous
		implementing complex		vessels
		AI models		

### **Big Spatiotemporal Maritime Data Pre-analysis**



# Big AIS data pre-analysis

- Methods deal with errors and missing data developed for AIS data considering its applications and features
- Compress to retain essential information for storage reduction
- Improve analytics efficiency: 400 time more size reduction



### Trajectory reconstruction

- Al-based learning from historical trajectories
- High quality reconstruction
- Provide inputs for port/vessel operation and traffic safety management via trajectory reconstruction

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# **Deep Learning Architecture for Traffic Safety Study**

**Objective**: incorporating multi-modal data into AI modeling for time-ahead prediction **Methodology**: deep learning approach **Outcomes targeted**: novel AI research for traffic safety enhancement



### **Concurrent/parallel Computing for Trajectory Prediction**



#### Actor model based concurrent computing system (cluster to enable advanced forecasting services in near real-time)

Zhe Xiao, Xiuju Fu, Liye Zhang, Wanbing Zhang, Ryan Wen Liu, and Rick Siow Mong Goh, "Big Data Driven Vessel Trajectory and Navigating State Prediction with Adaptive Learning, Motion Modeling and Particle Filtering Techniques", IEEE Transactions on Intelligent Transportation Systems, 2020 Zhe Xiao, Xiuju Fu, Live Zhang and Rick Slow Mong Goh, "Traffic Pattern Mining and Forecasting Technologies in Maritime Traffic Service Networks: A Comprehensive Survey," in IEEE Transactions on Intelligent Transportation Systems, 2019 Zhe Xiao, Live Zhang, Xiuju Fu, Wanbing Zhang, Joey Tianyi Zhou, Rick Siow Mong Goh, "Concurrent Processing Cluster Design to Empower Simultaneous Prediction for Hundreds of Vessels' Trajectories in Near Real-Time," in IEEE Transactions on Systems, Ann, and Cybernetics: Systems, 2019 Zhe Xiao, Loganathan Ponnambalam, Xuju Fu and Wanbing Zhang, "Maritime Traffic Probabilistic Forecasting based on Vessels' Waterway Patterns and Motion Betaviours", IEEE Transactions on Intelligent Transportation Systems, 2017 Copyright @ IHPC 2020, All in Christ Transportation Systems, 2017

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### **Operational Events Detection: Operation Insights & Tracking**

**Motivation:** Decipher **Vessel Operation Events** (berthing, anchorage, bunkering, slowing down) for future happenings to benefit operations and planning to improve efficiency.



Outcomes:

A system based on **AI** approach for realtime vessel operation event and historical detection, events which is **applicable to** other ports Automated detection of details of vessels/fleets operations and automating port operation reports.

# Federated Learning for Maritime Data Privacy and AI

**Objective**: fully capture data intelligence by consolidating isolated data in the past and secure data privacy

**Methodology**: collective learning, not exchanging/centralizing data **Outcomes targeted**: open novel research and business avenues and has the potential to improve in maritime sector

Federated Learning for Enlarging Data Scale with Privacy Preserving





N. Rieke *et al.*, "The future of digital health with federated learning," *npj Digit. Med.*, vol. 3, no. 1, pp. 1–7, Sep. 2020, doi: 10.1038/s41746-020-00323-1. Copyright @ IHPC 2020. All rights reserved.

#### Use case 1: Optimize the Voyage using Federated Learning

#### Objectives:

- Route generation with FL for spatial-temporal optimisation
- Global optimisation using different parties' data in privacy preserving way for insight generation



#### Use case 2: Optimize the Bunkering Services

#### **Objectives:**

- Improve barge utilization
- Reduce the number of barges to fulfil the same load of bunkering services
- Decision making on scheduling and service arrangement



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### **Summary**

- Al is with big potential for its application in maritime operations
- IHPC maritime research:
  - Al-based modeling and optimization considering complex system behaviors for system improvement
  - HPC based analytics, simulation and optimization methodologies development and quantum computing based exploration
  - Research and applications development experiences in traffic safety and port operation efficiency enhancement
  - New research in **maritime emission** related study





# **THANK YOU**

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