Centre for Maritime Digitalisation
A*STAR C4MD

Accelerating Innovations in Maritime Shipping Through Maritime AI Research

Maritime AI Research Programme

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Outline

- How is AI transforming key aspects of maritime shipping
- How can industry collaborate with research institutions to accelerate maritime AI adoption
- What are next research topics for advancing maritime AI development
- What are the biggest challenges in integrating AI into maritime shipping, and how to overcome

Interest on the rise

The number of organisations involved in maritime AI has increased significantly between 2023 and 2024 [1]

US$4.13B

2024 Maritime AI market size with 5Y CAGR of 23% [1]

AI is used various aspects

Maritime AI

in numbers

Asia is a fast-growing market

[1] https://www.lr.org/en/knowledge/research-reports/2024/beyond-the-horizon/
[2] https://www.forbes.com/sites/gilpress/2016/03/23/data-preparation-most-time-consuming-least-enjoyable-data-science-task-survey-says/
[3] https://m.mage.ai/how-long-does-it-take-to-build-an-ml-model-d68b8afa50a5

Application of AI in the Maritime Industry

The application of AI in the maritime industry offers an expansive degree of machine learning driven **automation applications** to aid maritime operators in supporting operational and environmental regulatory compliance, and dealing with growth and intricacies associated with the trade.

It is essential to capture potential market value by integrating new digital tools flexibly while keeping current operation systems running reliably.

Application of AI in the Maritime Industry

A1. Vessel

- Autonomous navigation
- Situational awareness
- Route recommendation and ETA prediction

A2. Personnel

- Language assisted ship-to-shore communication
- Customer segmentation
- Crew logistics and scheduling
- Crew training and monitoring

A3. Port and cargo Operations

- Fleet management and allocation planning
- Berth scheduling
- Supply chain logistics
- Cargo management

A4. Maintenance and Monitoring

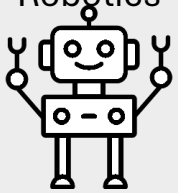
- Predictive maintenance and scheduling
- Speed adjustments from fuel consumption modelling
- Structural health monitoring

Expanded descriptions of each section can be found in the attachment.

A5. Cybersecurity

- Security information and event management systems
- Data sharing for planning and decision support
- Blockchain

A6. Robotics



- Inspection, delivery and search-and-rescue drones
- Automated ground vehicles

How could AI transform key aspects of maritime shipping

- Examples of maritime AI applications under the maritime AI Research Programme

Maritime AI Research Programme in Singapore

A systematic approach for maritime AI and digitalisation development

11 companies onboard

15 Nov 2022- 14 Nov 2024

Funded by Singapore Maritime Institute (SMI)

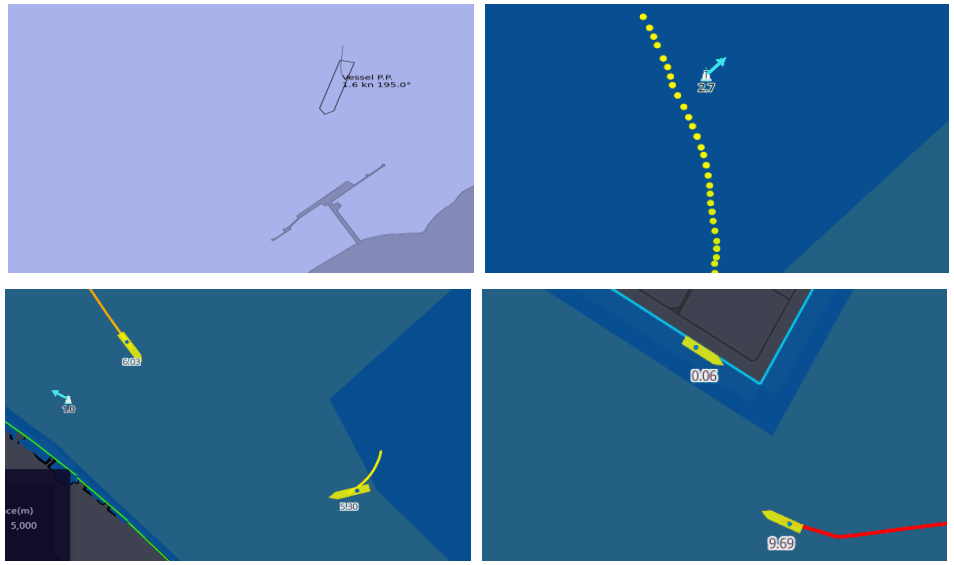
Key Outcomes & Recognition of Phase 1 - Traffic Safety

Maritime Traffic Safety: from research models to live ops trial, towards NG-VTMS

The automated detection results added around **90%** records to the near-miss case set, time saving of **75%** for critical case identification, **50%** increase in case reporting, representing enhancement in safety perception and targeted mitigation.

Innovative AI tools for automating near miss case detection, leveraging on domain knowledge

- 4 detection engines developed: ship to ship, ship to berthing, ship to buoy, ship to anchored ship



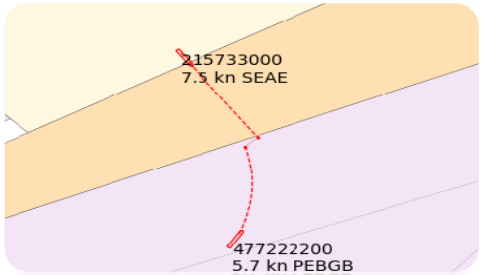
Real-time traffic-based trial is ongoing, deployed in operational environment for 7+ months

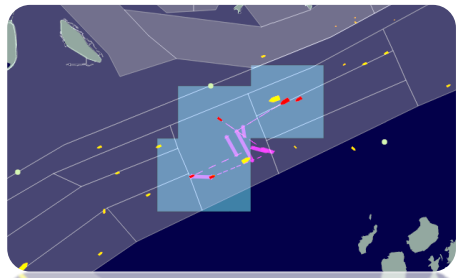
- Performance is **received well** by domain expert in practical operations

Key Outcomes & Recognition of Phase 1 - Traffic Safety

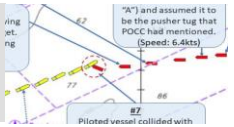
Maritime Traffic Safety: from research models to live ops trial, towards NG-VTMS

Innovative near miss/collision detection with presentation to IALA DTEC committee





Singapore strait (SG VTS sectors)

ship-to-ship		ship-to-infra.	
Type 1:both underway		*Type 1: jetty(berthing)*	
Type 2:Anchored		*Type 2: jetty(underway)*	
Type 3:Berthed		*Type 3: buoy(underway)*	

Within Singapore port water

- Deployed at POCC for live ops trial to **provide near miss cases daily** with the previous day's cumulative AIS data
- Presented to **MPA-SSA SAFENAV Workgroup**
- Invited to present **an information paper at IALA committees**, in collaboration with MPA
- **Supporting NG-VTMS prototyping** by providing traffic safety modules for benchmarking and Open System Architecture assessment
- Expanded to port water with tools to detect ship-to-ship and ship-to-infra near miss cases, **licensing discussion ongoing**

Over

90%

unreported near-miss case detected
(based on IHPC's evaluation)

Enhancement in

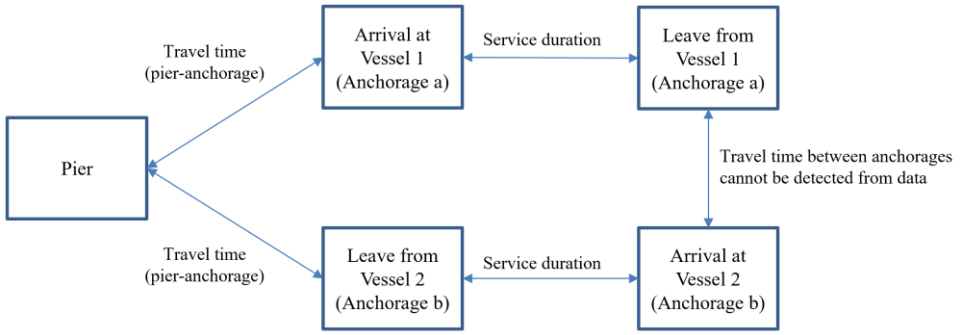
Unreported cases detected
&
Led to more manual reporting

(with 4 detection models)

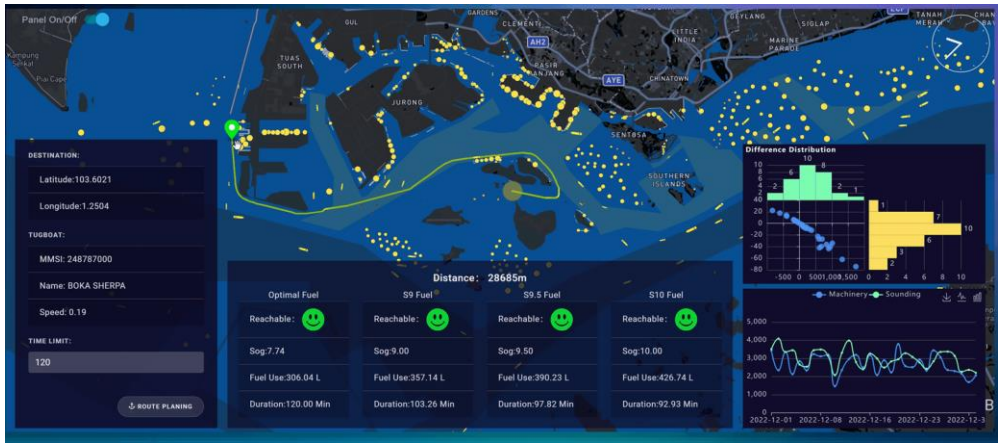
New AI Tools with Quantified Results - Green Technologies

Decarbonisation & Harbour Craft Optimisation: AI-based soft tech solutions

Optimising harbour craft for port services



Launch boat job batching



Harbour tug transit fuel optimisation

- **Over 25% travel distance reduction** with AI-based launch boat batching, planned deployment on platform eLSA.
- AI based tools with **20% fuel consumption reduction, 671.40 Tonnes emission reduction** per tug per year (3 tools: daily operation performance monitoring, sensor failure identification, route & speed recommendation). Next step on deployment for continuous sea trial
- Supported MESH with **big data-based harbour craft operation event analytics**

Up to

115K

CO_2

Tonnes of CO_2 to be saved

(Tugboats & launch boats by end of 2024)

Approx.

$4.8M

(USD)

$

Cost savings expected per year

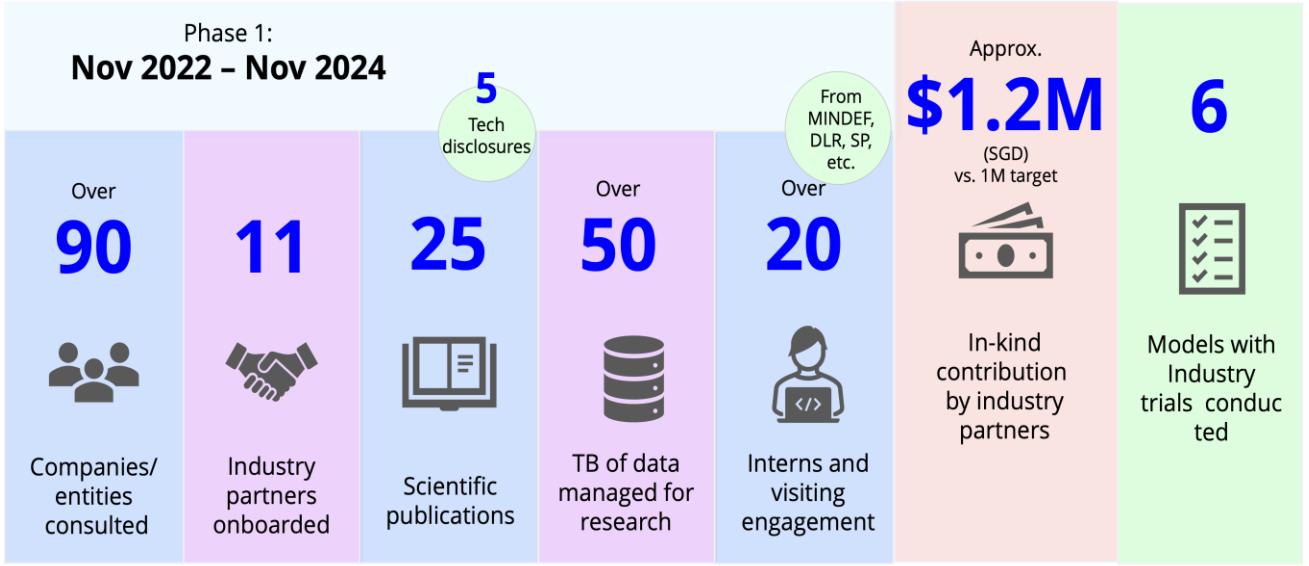
How can industry collaborate with research institutions to accelerate maritime AI adoption

Joint Force for Maritime AI R&D to Support the Long-term Development

Maritime AI Research Programme

Delivering competitive AI capabilities and solutions in maritime decarbonisation, vessel traffic safety and smart shipping.

- Big databank establishment
- Maritime AI modeling and model accumulation
- High TRL deliverables and key technical capabilities
- Key maritime AI talents development and training
- Key partnership and maritime AI knowledge dissemination for better preparing industry in AI development and adoption



Grantor, Industry and Research Collaborators:

11 industry partners

What are next research topics for advancing maritime AI development

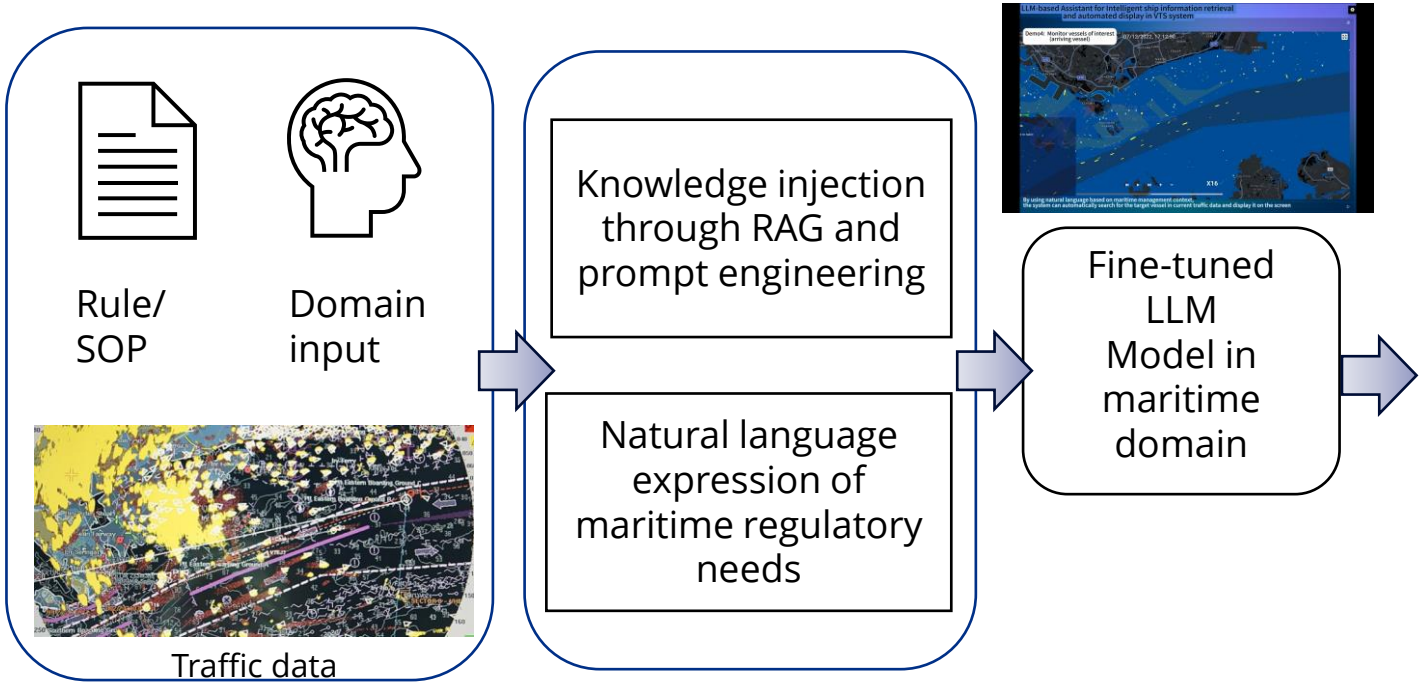
Multimodal AI (MLLM) for Assisting Maritime Traffic Management

Input:

- AIS, Radar, ECDIS, Navigation Rule, videos, VHF voices and Natural language expression of maritime regulatory needs

Output:

- Multimodal results according to contextual input:
  - Text for vessel identification and Traffic situation awareness
  - Images for visualizing traffic analysis and planning
  - Voice complying with best maritime supervision practices for real-time operation



Multimodal outputs for traffic safety management decision support

- **Text for vessel identification and Traffic situation awareness**
  - **Examples:** Which vessels are expected to enter the port in the next x minutes? Display them.
  - list vessels that exited a specific channel and continued westbound along the strait, show me the trajectory and density image categorized by vessel type and length
- **Voice for basic operator communication**
  - **Example:** Please suggest better maritime VHF communication to remind vessels for navigational safety based on their current encounter situation.
  - Example: please convert my instruction into messages for MASS navigation

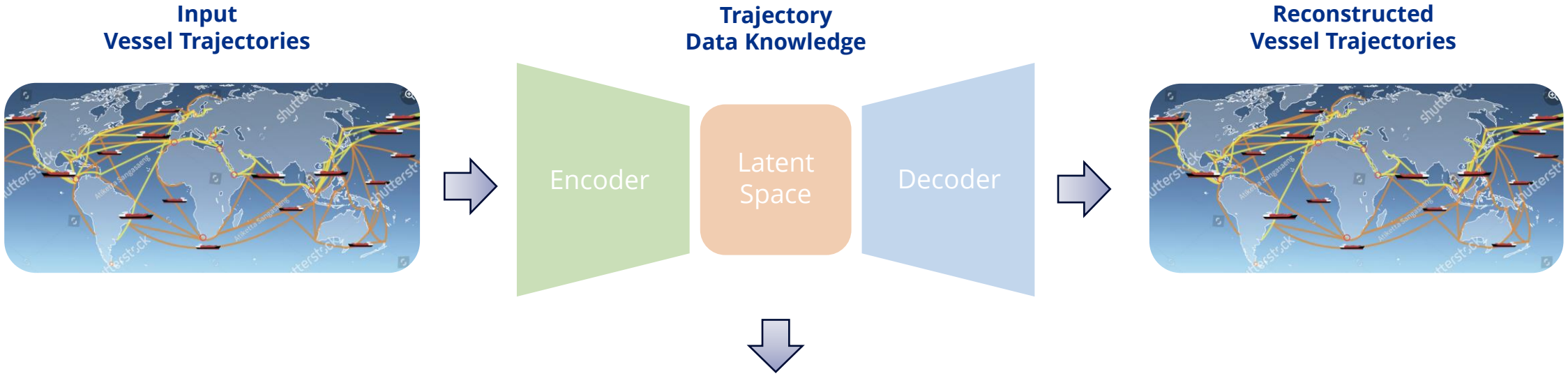
Benefit:

Enhancing efficiency through intelligent and automatic data retrieval and analytics
Reduce workload and minimize human errors by automating basic and simple voice operations

Maritime GPT for Vessel Trajectories and Locations

Construct a foundational model to learn the marine vessel trajectory data distribution.

hybrid encoder-decoder architecture



Maritime Traffic GPT for Downstream Tasks

Trajectory reconstruction and prediction:

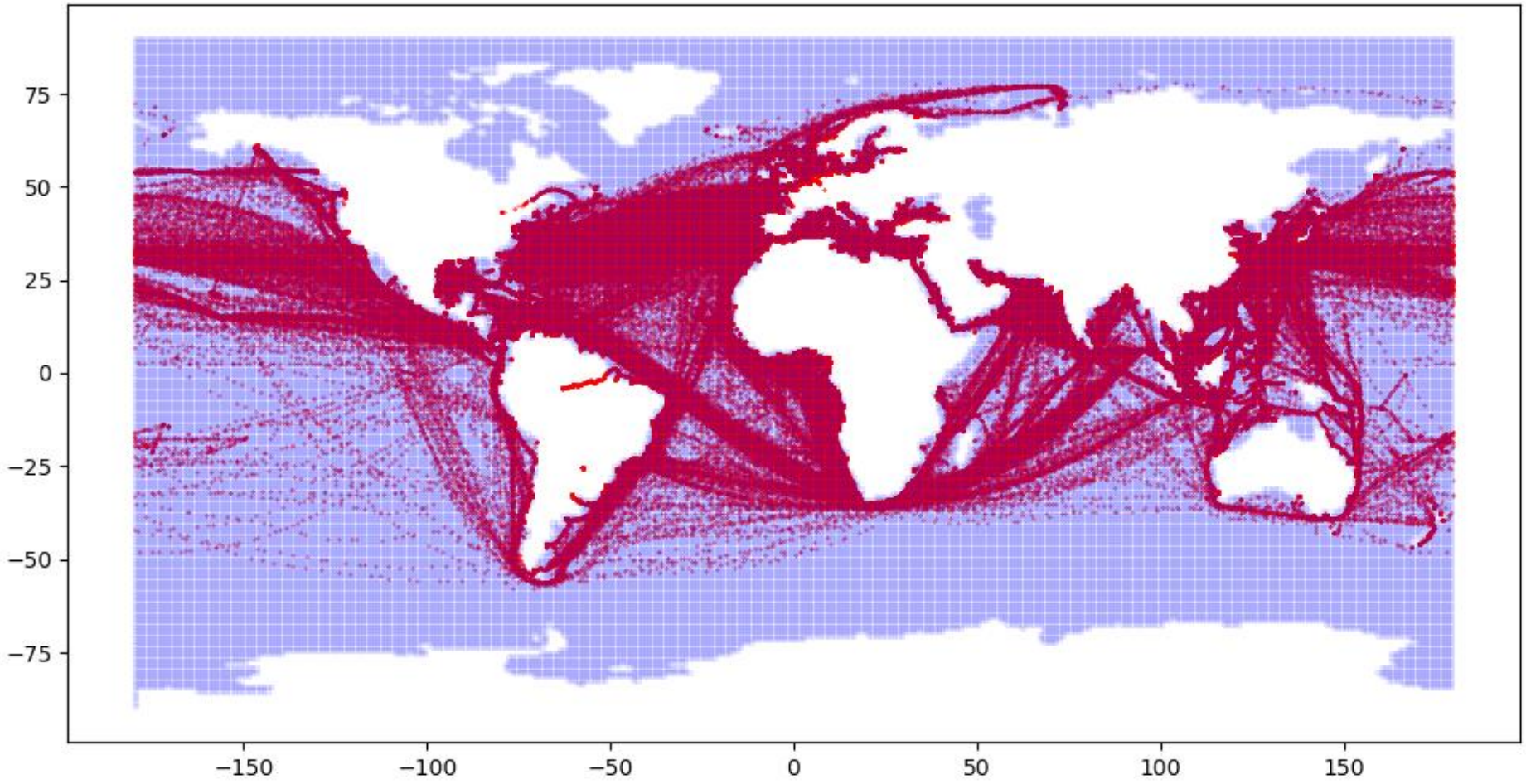
With some segments of historical trajectory given, predict the subsequent/missing trajectory.

Vessel next location prediction:

With the ship's name/ID given, predict the ship's next location up to 30+ days ahead.

Maritime Traffic GPT for Vessel Trajectories and Locations

Current progress on training: Input (Global traffic data of 30 days)



Maritime Traffic GPT for Vessel Trajectories and Locations

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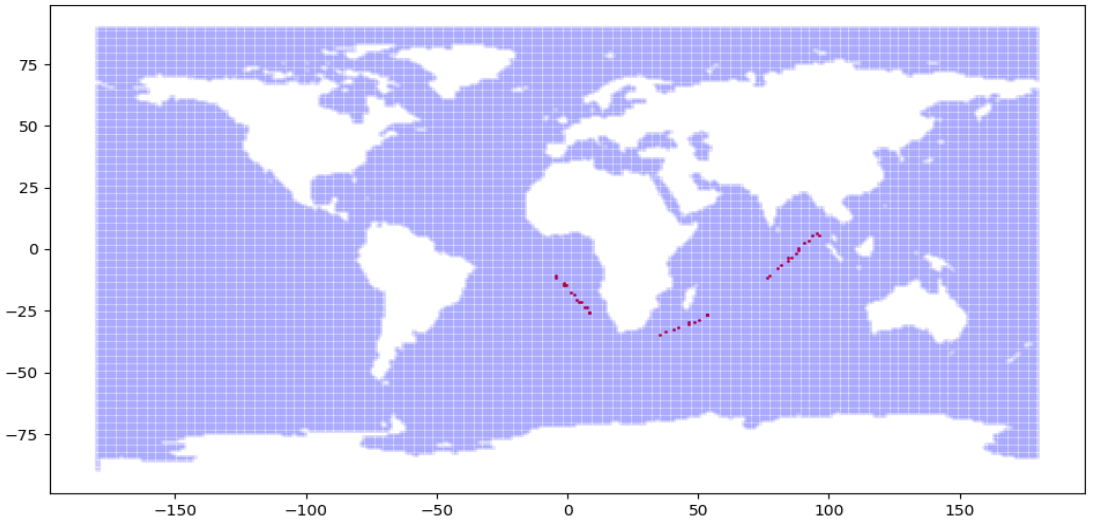
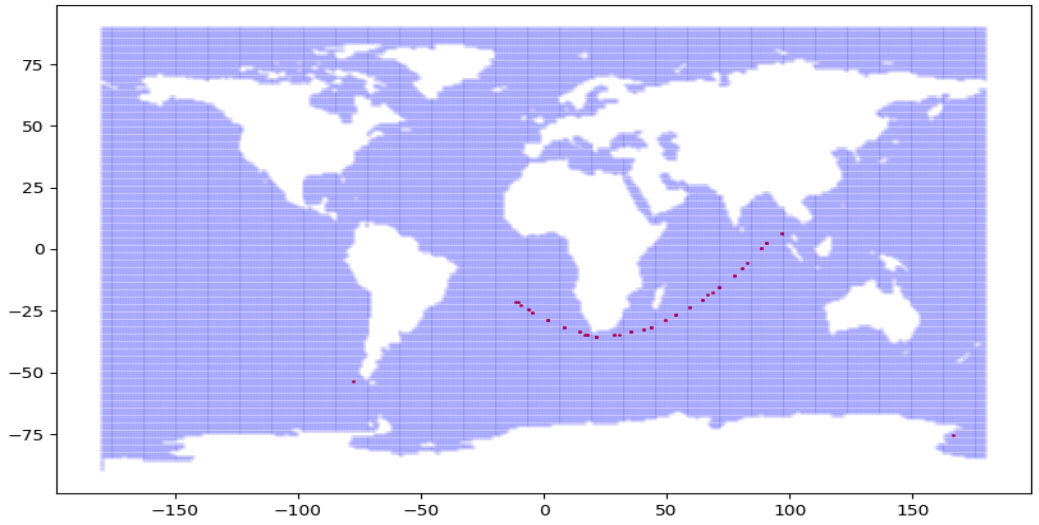
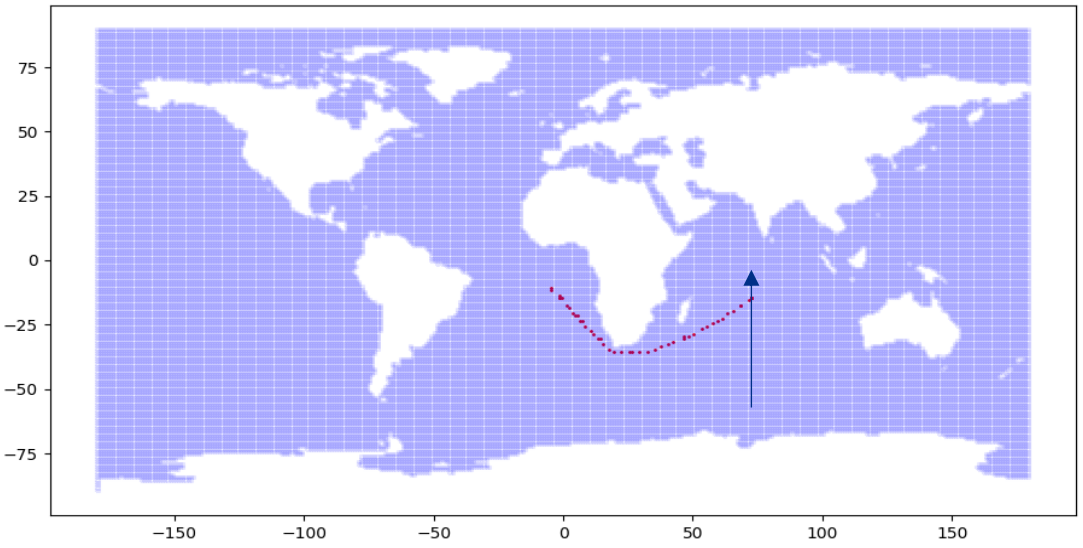


Task 1: multiple segments missing

Traffic GPT

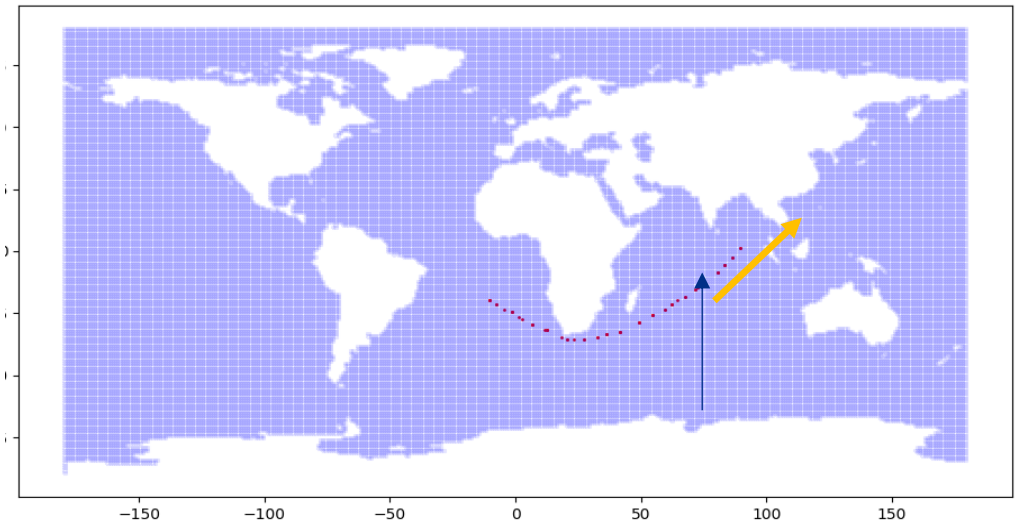


Reconstruction



Task 2: next location and trajectory

Traffic GPT



Trajectory and location prediction

What are the biggest challenges in integrating AI into maritime shipping, and how to overcome

Challenges in Maritime Data / AI Initiatives

Expensive model building

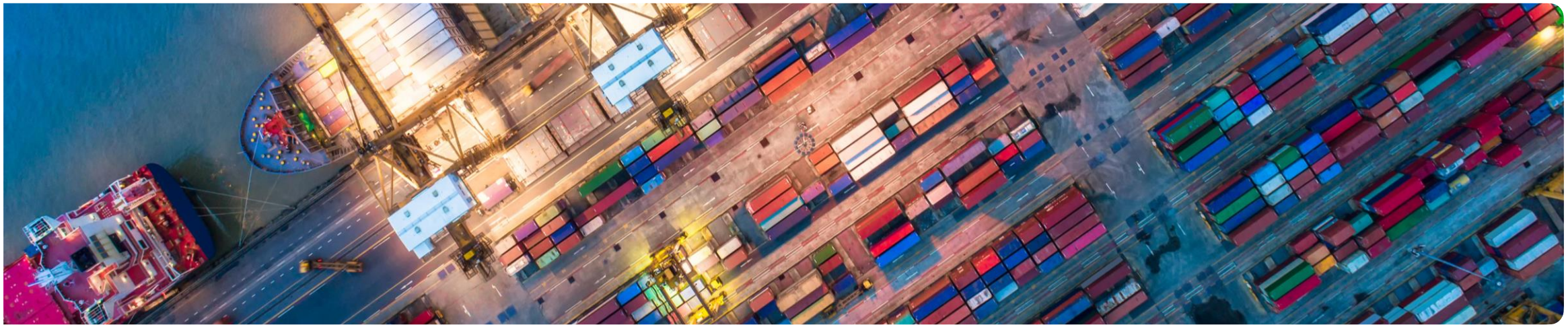
Building high-quality AI-based models is costly and requires extensive domain knowledge

Poor data quality

Raw datasets often contain inaccurate or corrupted information that implicates model quality

Isolated efforts

Limited data / knowledge sharing and collaboration results in duplicated efforts and inefficiencies



systemmax

maritime **AI** e**x**cellence

System max

- System for Maritime Ai eXcellence

A system that provides comprehensive enabling technologies/tools through **foundational modules** to help systematically synergise maritime AI techstack

- ✓ Accelerate adoption of AI
- ✓ Trustworthy and reliable AI
- ✓ Enhanced visibility and collaboration

Key foundational modules specifically designed for maritime AI development:

max**Databank**

Repository for maritime datasets with metadata

max**Modelstore**

Store for AI models for various maritime use-cases

max**GPT**

RAG-based chatbot that links maritime models and data

max**Assessor**

Tools for data quality assessment and diagnosis

max**Processor**

Data enhancement tools for maritime datasets

max**Valuator**

Tools that provide a basis for data monetisation

max**Tester**

Model performance testing / diagnosis for trustworthy AI

max**Trainer**

Tools for expediting maritime AI model training

Preliminary system max at a Glance

maxGPT linking users with maritime data and models

What is the accuracy of DeepSeaTraj model?

The accuracy of DeepSeaTraj model is 0.95.

maxDataBank
50TB+
described using data metadata

maxModelStore
40+
described using model metadata

maxAssessor
17 metrics
Quality check for AIS data and sensor data

maxTester
11 evaluation metrics

maxProcessor
15 algo.
Reduces processing time from days to minutes

Let's join forces to shape the future of Maritime AI

Centre for Maritime Digitalisation
A*STAR C4MD

Join Us in Maritime AI Cluster under INFORMS International 2025

https://meetings.informs.org/wordpress/2025international/cluster-chairs/

Five sessions:

1. AI for **Vessel Traffic Management**
2. AI for **Maritime Decarbonization**
3. AI for **Smart Ports**
4. AI for **Logistics, Supply Chain and Trade**
5. AI for **autonomous shipping**

INFORMS INTERNATIONAL CONFERENCE 2025
MARITIME AI CLUSTER
SINGAPORE | JULY 20-23, 2025

Background

Artificial Intelligence (AI) is playing an increasingly vital role in transforming maritime transportation systems. By processing vast amounts of data, uncovering complex relationships, and optimizing operations across maritime operators, vessels, terminals, ports, and shipping networks, AI has the potential to revolutionize the industry. It paves the way for a greener, safer, more efficient, and more sustainable maritime transportation and shipping sector.

This maritime AI cluster aims to facilitate meaningful discussions and knowledge exchange on AI-driven innovations and best practices in maritime transportation systems and shipping operations.

Five sessions are included under Maritime AI Cluster:

1. 212: AI-Driven Innovation in Maritime Traffic Management
   Chaired by Dr Wang Ke (wang_ke@ihpc.a-star.edu.sg)
2. 213: Accelerating Maritime Decarbonization with AI
   Chaired by Dr Yan Ran (yan.ran@ntu.edu.sg)
3. 214: AI for Smart Ports
   Chaired by Dr Li Haobin (li_haobin@nus.edu.sg)
4. 215: AI in Maritime Logistics, Supply Chains, and Global Trade
   Chaired by Dr Mikael Lind and Wolfgang Lehmacher (mikael.lind@ri.se)
5. 216: Navigating Autonomy: AI for Ship Operations and Navigation
   Chaired by Dr Liu Jingxian (101018056S@qq.com)

Abstract Submission (please write to session chairs directly)

Abstract submission only in less than 250 words in English by April 16, 2025 11:59PM EST.
Please refer to https://meetings.informs.org/wordpress/2025international/submit/ for more information.

Maritime AI Cluster:

Chair of Maritime AI Cluster:

Dr Fu Xiuju
Senior Principal Scientist, A*STAR IHPC

Dr Li Haobin
Senior Lecturer, NUS ISEM

Chair of Session 212 (AI-Driven Innovation in Maritime Traffic Management):
Dr Wang Ke, Scientist, A*STAR IHPC

Chair of Session 213 (Accelerating Maritime Decarbonization with AI):
Dr Yan Ran, Assoc. Professor, NTU CEE

Chair of Session 214 (AI for Smart Ports):
Dr Li Haobin, Senior Lecturer, NUS ISEM

Chair of Session 215 (AI in Maritime Logistics, Supply Chains, and Global Trade):
Dr Mikael Lind, Senior Strategic Research Advisor, RISE and Wolfgang Lehmacher
partner of Anchor group

Chair of Session 216 (Navigating Autonomy: AI for Ship Operations and Navigation):
Dr Liu Jingxian, Professor, Wuhan University of Technology, School of Navigation

Build better maritime AI models, faster, together

Dr Kelvin Lee

Dr Wang Ke

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THANK YOU

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