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Enhancing Vessel Estimated Time of Arrival Prediction through Vessel Event Detection and Data Augmentation

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1. Introduction: Importance & Challenges

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Crucial role in maritime logistics

- Operational Efficiency:
  - Help ports optimize docking schedules
  - Minimize waiting times and streamline cargo handling
- Supply Chain Impact: increase visibility and facilitate downstream planning
- Commercial Advantage: Companies that can predict ETAs more accurately can improve customer satisfaction and gains a competitive edge.

Challenges:

- Dynamic factors: Weather, ocean currents, etc.
- **Global-scale ETA prediction**: Expanding prediction models to accommodate global maritime networks is a significant challenge.

1. Introduction: Objective and Overview

Objective

- Develop a framework to enhance vessel ETA prediction accuracy
- Applicable to Global-scale ETA prediction: Given a position in the sea and a target port (destination), predict the travel time between them
- Dynamically update and refine ETA predictions as voyages progress

Overview: two-step development

- Step 1: Vessel event detection
- Step 2: Data processing and machine learning pipeline selection

2. Vessel Event Detection

AIS data

Vessel Event Detection

Travel legs
- Vessel IMO
- Departure event
- Arrival event to the subsequent port

- Preprocess raw AIS data

- Vessel Event Detection:
    - Input: Processed AIS data
    - Develop based on DBSCAN

IMO	From	To	Travel Time[h]	Travel_Start	Travel_End
8512279	SGSIN	CNYNT	259.63	19/2/2023 3:44	1/3/2023 23:22
8700254	SGSIN	CNSHA	193.32	7/1/2020 2:21	15/1/2020 3:40
8902967	SGSIN	CNMWN	186.18	26/1/2023 10:33	3/2/2023 4:44
9048122	SGSIN	CNCFD	296.15	3/4/2020 16:09	16/4/2020 0:18
9081801	SGSIN	CNXMN	139.07	10/4/2023 6:34	16/4/2023 1:38
9134622	SGSIN	CNNGB	169.73	15/4/2022 0:39	22/4/2022 2:23

3. Data extraction and feature expansion

- Extract AIS data for the identified travel legs
  - A vessel’s trajectory between two ports and its travel time

- Feature expansion:
  - Vessel type
  - Dimensions: vessel’s length and width
  - Vessel current position
  - Vessel destination: the lat and lon of a port
  - SOG (current speed over ground)
  - Draft: loading
  - Month: ocean current information)

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3. Example of training data

Vessel Type	Vessel lat	Vessel lon	Destination lat	Destination lon	Length	Width	Draught	SOG	Month	Remaining_Travel_Time[h]
Cargo	-20.418645	113.130748	-33.31790479	115.6555239	190	28	6.3	10.2	5	75.51
Cargo	-20.76018	113.05003	-33.31790479	115.6555239	190	28	6.3	10.5	5	73.52
Cargo	-21.114613	112.96827	-33.31790479	115.6555239	190	28	6.3	9.8	5	71.35
Cargo	-21.43374	112.900167	-33.31790479	115.6555239	190	28	6.3	9.4	5	69.33
Cargo	-21.706898	112.841097	-33.31790479	115.6555239	190	28	6.3	9.4	5	67.51
Cargo	-22.045553	112.762337	-33.31790479	115.6555239	190	28	6.3	10.3	5	65.33
Cargo	-22.379438	112.683188	-33.31790479	115.6555239	190	28	6.3	10.8	5	63.45
Cargo	-22.717872	112.610652	-33.31790479	115.6555239	190	28	6.3	11	5	61.52
Cargo	-23.110263	112.505717	-33.31790479	115.6555239	190	28	6.3	11.1	5	59.34

Features

ETA

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Case Studies

Period: January 2020 to June 2023

AIS data resolution: bi-hourly

Use cases

- Singapore-China Shipping Line
- Europe Asia-pacific Maritime Corridor

Machine learning pipelines

- XGBoost, ANN, Random Forest
- **After fine tuning, XGBoost performs the best in all use cases**

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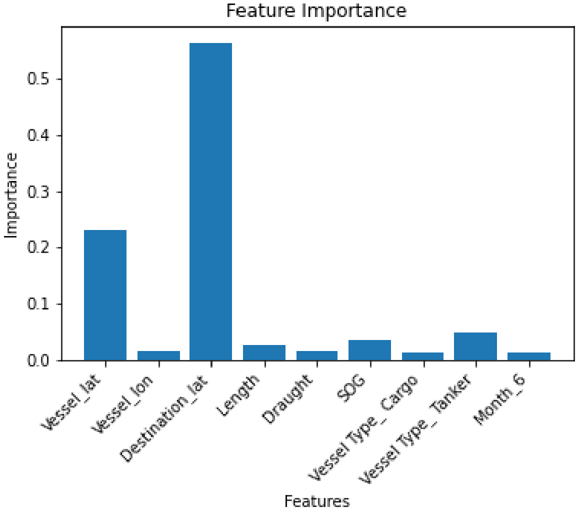
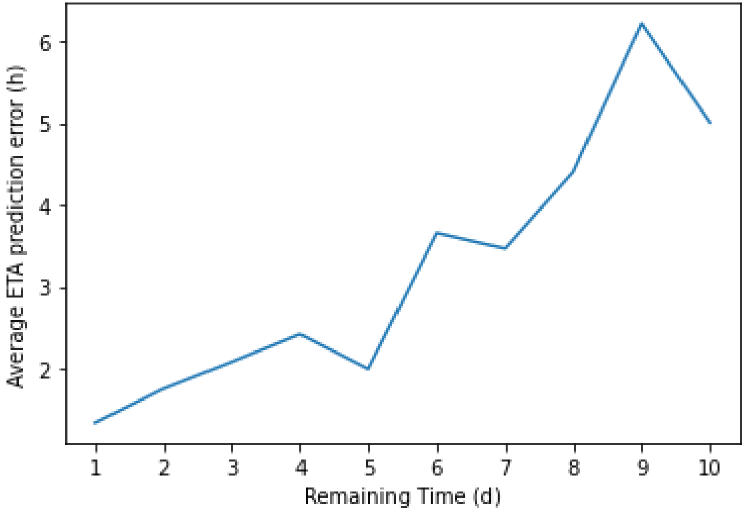
Singapore-China Shipping Line (47 ports)

- 355 vessels
- 965 travel legs
- 27,302 lines of training data
- **Testing MAE: 2.43 hours**

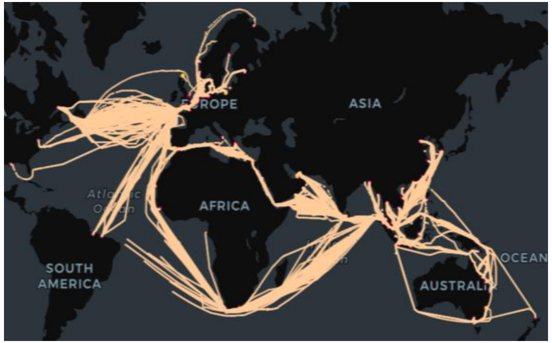
Only show feature with importance > 0.01





Europe Asia-pacific Maritime Corridor

- 1,208 vessels
- 3,694 travel legs
- 272,558 lines of training data
- **Testing MAE: 3.3164 hours**



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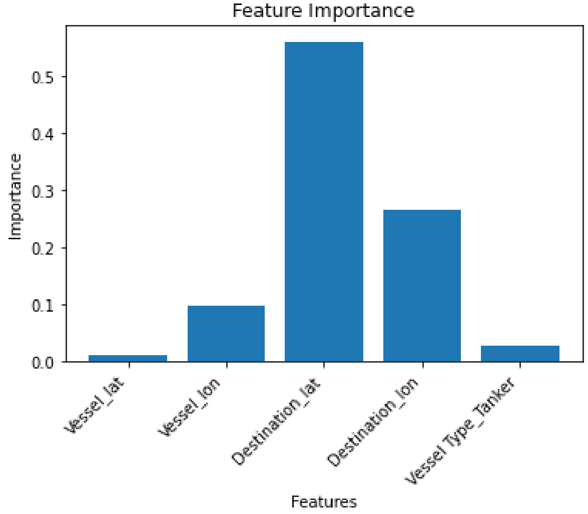

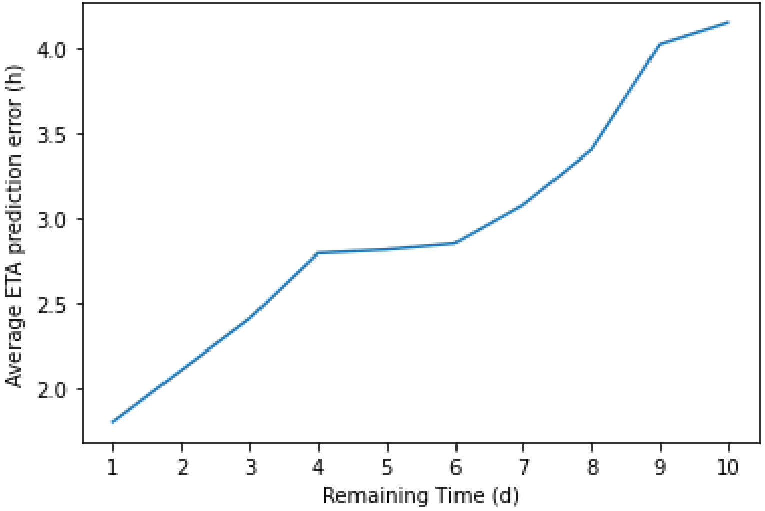

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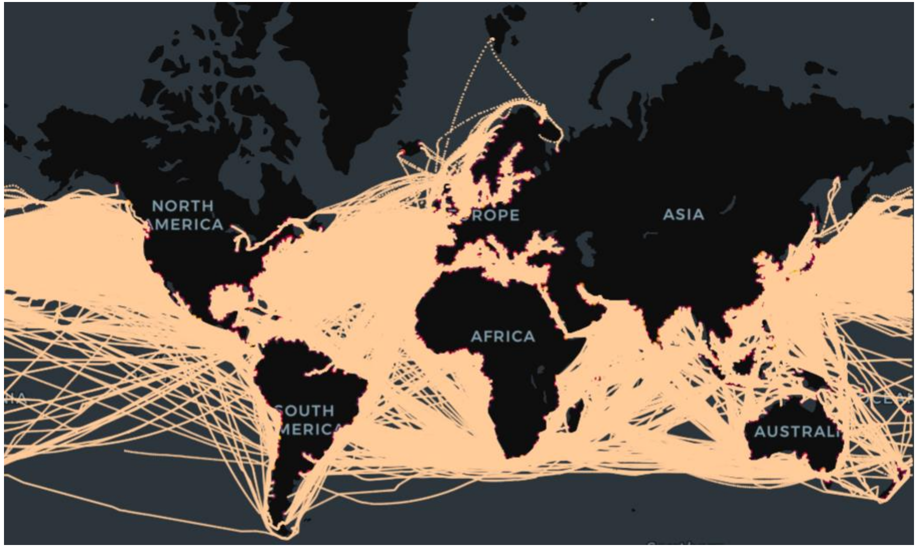
Conclusion

- Proposed a framework from AIS data to effective ETA prediction
  - Event detection from AIS data for identifying travel legs
  - Feature expansion

- Future work: Global-scale Maritime Network



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THANK YOU

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