IALA Internship Presentation

By: Neha Devi Shakya
On: 31 August 2023

Table of contents

01 Introduction

02 About the AIS Data

03 Theory for Detecting Near-Misses and Trajectory Prediction

04 Results

05 Limitations

06 Conclusion

01

Introduction

Introduction: Overview of IALA and its Function

- A global non-profit organization established in 1957, focused on enhancing maritime navigation safety, efficiency, and environmental sustainability through collaboration and standardization.
- Serves as a central hub for various stakeholders involved in Marine Aids to Navigation (AtoN), including authorities, manufacturers, consultants, scientific institutions, and training centers from around the world.
- Core function: offer a platform for the exchange and comparison of experiences and achievements related to Marine Aids to Navigation.

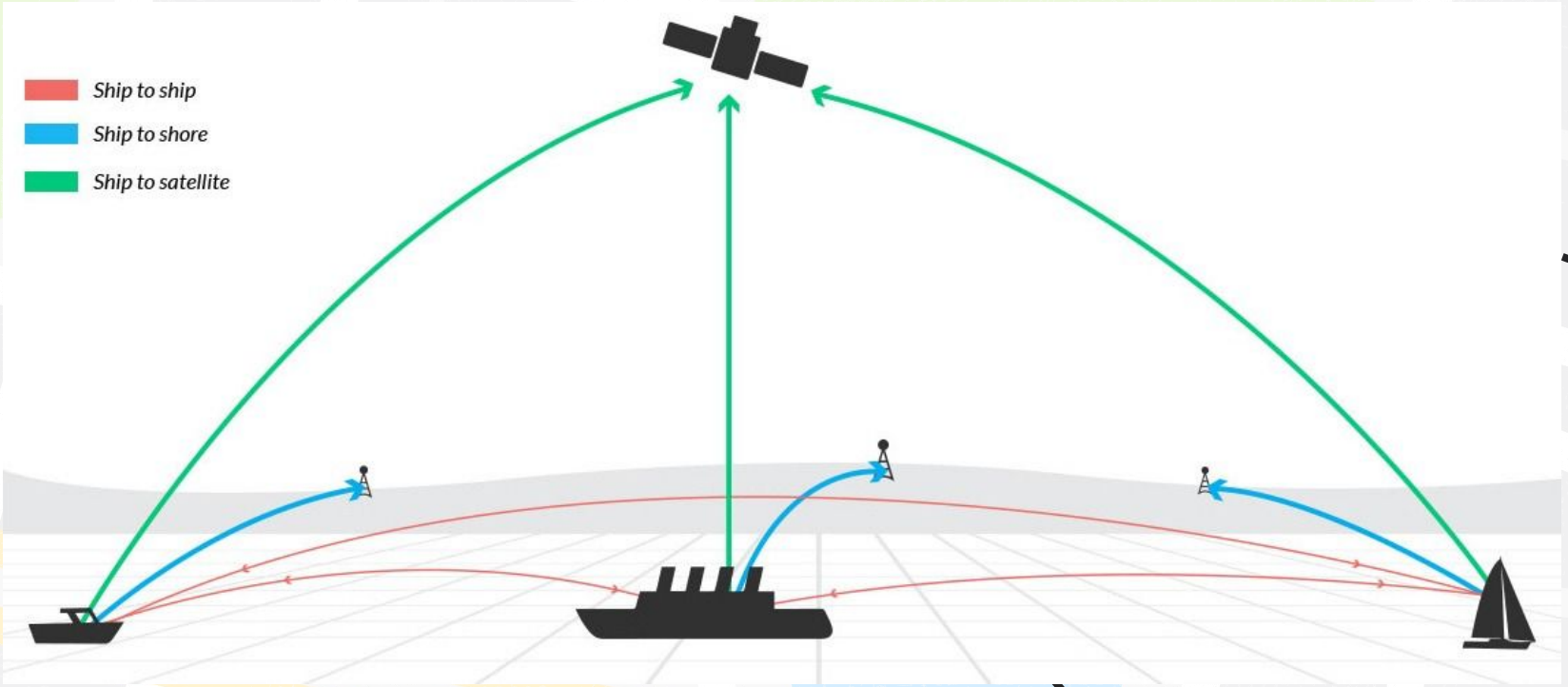
Introduction: Overview of the Internship

- Duration: April to August 2023 (5 Months)
- Main Mission: Decode historical AIS data and analyse it.
- My Tasks:
  - Research any existing approaches to detect any near-miss collisions in the data
  - Implement valid approach on the decoded data
- Khushi’s Tasks:
  - Research any existing approaches to predict the shortest route between two ports
  - Implement approach on the decoded data

Overview on AIS data

- AIS stands for Automatic Identification System, a technology used by ships to broadcast information about their position, speed, heading, and other data to other ships and to shore-based stations.
- It has revolutionized the way ships navigate, communicate, and operate, leading to improved safety, efficiency, and security in the world's oceans.
- It has become an indispensable tool for vessel tracking and monitoring, maritime safety and security, environmental protection, traffic management, and commercial analysis.

Overview on AIS data



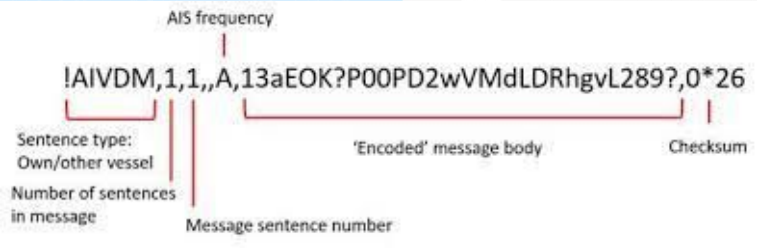
02

Data Decoding and Preprocessing

Area of Study

For my task the main area of study was the Denmark waters.

Decoding the data



Example Message:

$PGHP,1,2022,1,3,9,10,33,483,250,,2500370,1,63*25

!BSVDM,1,1,,B,1CfJtSPP?wOBa=BMSPuv4?wp0p@<,0*63

Message Format:

- Gatehouse Wrapper
  - $PGHP,<msgtype>,<date format>,<country>,<region>,<pss>,<online data>,<cc>*hh<CR><LF>
  - Date format=<year>,<month>,<day>,<hour>,<minut>,<second>,<millisecond>
- AIS message

Cleaning the data

- Check if the values are against the AIS standard.
- Remove the position data with unavailable coordinates.
- Filter out messages with invalid MMSI numbers and IMO numbers.
- Remove coordinates that are not in the area of study.
- Filter out position messages with invalid course over ground and speed over ground of over 300 knots.
- Filter out vessels with less than 100 entries.

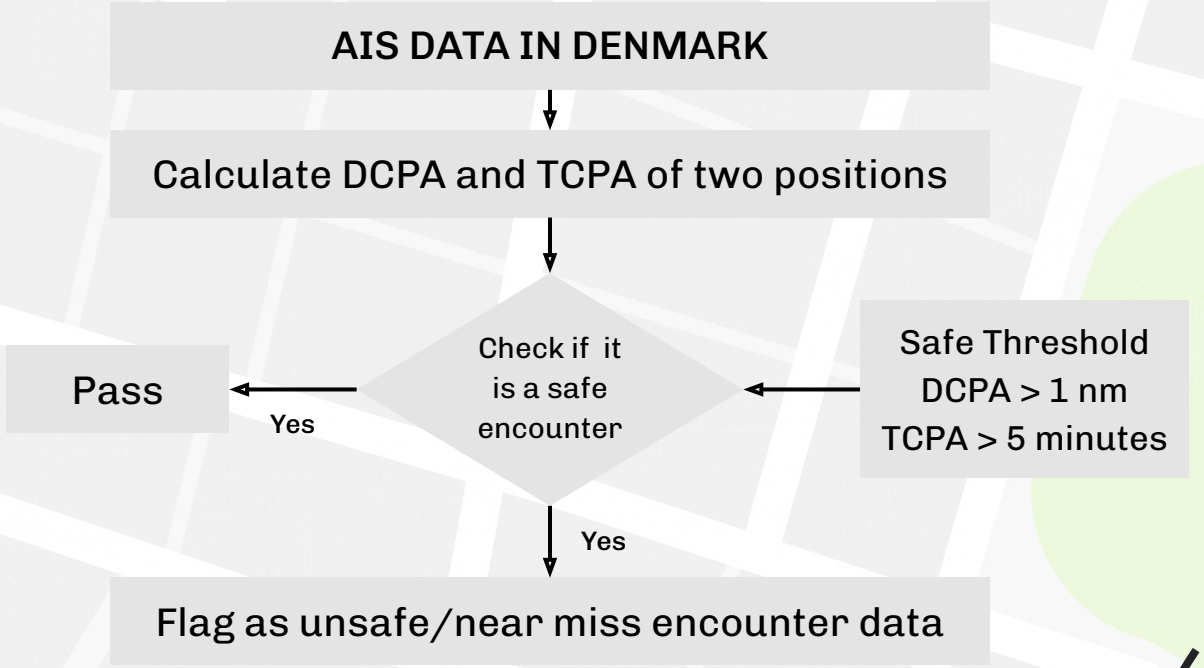
Filtering the ship types

Cargo Ships	Possible Cargo or not	Non-cargo Ships
Bulk Carrier	Cargo Hazard A	Fishing
Chemical Tanker	Cargo Hazard A (major)	Hopper Barge
Container ship	Inland Unknown	Hopper Dredger
Crude Oil Tanker	NULL	Military Ops
Fruit Juice Tanker	Other	Offshore Supply Ship
General Cargo	Unspecified	Passenger Ship
LPG Tanker		Research Vessel
Oil Products Tanker		Research/Survey Vessel
Oil/Chemical Tanker		Sailing Vessel
Ro-Ro Cargo		Tanker Barge
Ro-Ro/Container Carrier		Work Vessel
Tanker		
Vehicles Carrier		

03

Theory for Detecting Near-Misses and Trajectory Prediction

Flowchart of near miss classification analysis



TCPA and DCPA Equations

$$TCPA(t) = -\frac{[(y_j - y_i)(\dot{y}_j - \dot{y}_i) + (x_j - x_i)(\dot{x}_j - \dot{x}_i)]}{(\dot{y}_j - \dot{y}_i)^2 + (\dot{x}_j - \dot{x}_i)^2}$$

$$DCPA(t) = \sqrt{[(y_j - y_i) + (\dot{y}_j - \dot{y}_i) \times TCPA]^2 + [(x_j - x_i) + (\dot{x}_j - \dot{x}_i) \times TCPA]^2}$$

where,

x_i, y_i: position of own ship in x and y-axis

x_j, y_j: position of target ship in x and y-axis

$\dot{x}_i$, $\dot{y}_i$: speed component of own ship in x and y-axis

$\dot{x}_j$, $\dot{y}_j$: speed component of target ship in x and y-axis

$$\dot{x} = SOG\ sin(COG) \times \frac{1852}{3600}$$

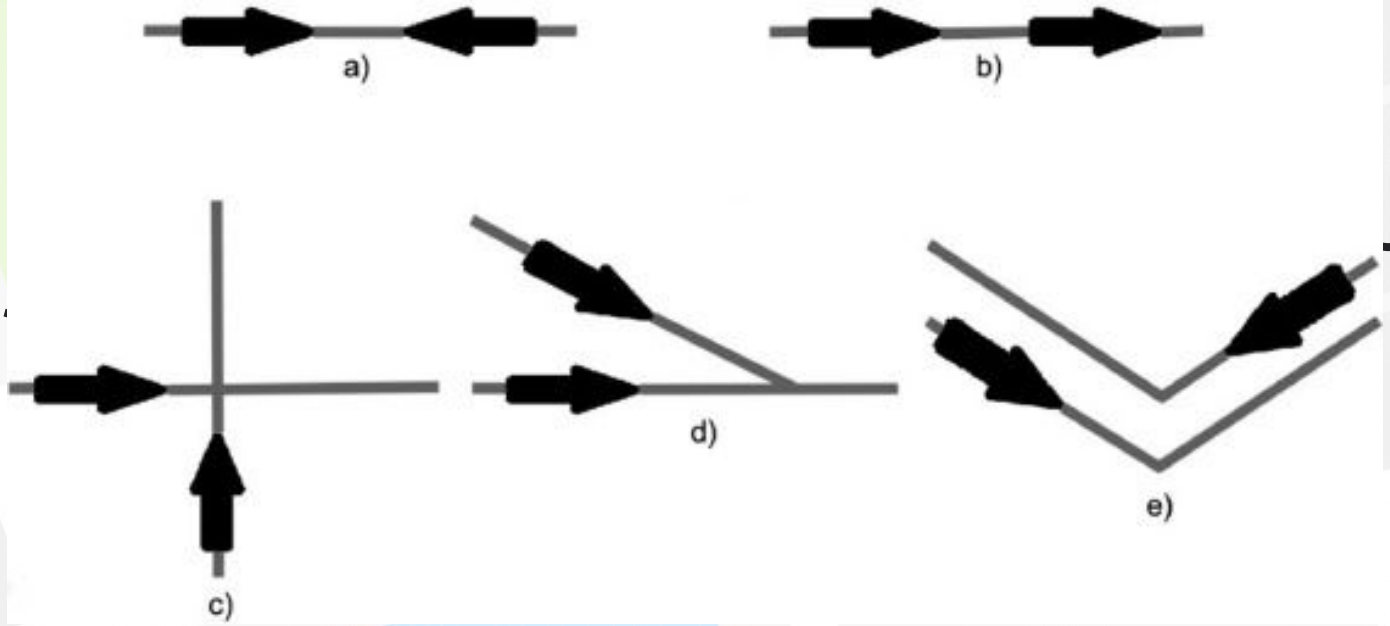
$$\dot{y} = SOG\ cos(COG) \times \frac{1852}{3600}$$

where,

SOG: The speed over ground of the ship

COG: The course over ground of the ship

TCPA and DCPA Equations



Theory for Route Prediction

- For prediction of the shortest route there had to be historical route data.
- In order to create the historical data we used cluster analysis and found groups for each route.
- Suppose our route contains n trajectories(sub-tracks) consisting of p latitude -longitude coordinate pairs and is placed as an n x 2p matrix.
- For each sub-track , we interpolated it such that each MMSI number has 100 points.

Theory for Route Prediction

$$
\begin{array}{c}
 \\
n \text{ objects}
\end{array}
\begin{array}{c}
\overset{2p \text{ variables}}{\overbrace{\phantom{(x_{11}, y_{11}) \cdots (x_{1f}, y_{1f}) \cdots (x_{1p}, y_{1p})}}} \\
\begin{bmatrix}
(x_{11}, y_{11}) & \cdots & (x_{1f}, y_{1f}) & \cdots & (x_{1p}, y_{1p}) \\
\vdots & & \vdots & & \vdots \\
(x_{i1}, y_{i1}) & \cdots & (x_{if}, y_{if}) & \cdots & (x_{ip}, y_{ip}) \\
\vdots & & \vdots & & \vdots \\
(x_{n1}, y_{n1}) & \cdots & (x_{nf}, y_{nf}) & \cdots & (x_{np}, y_{np})
\end{bmatrix}
\end{array}.
$$

Theory for Route Prediction

- We do not have the ship source and destination ports.
- So if a ship is within 5 km of a port and starts moving away from it, we set this as the start point.
- The sub-track end the ship stops moving.
- Use linear interpolation such that each sub-track has 100 points.
- Random forest to predict the shortest route.

Theory for Route Prediction

$$
\begin{array}{c}
 \\
n \text{ objects}
\end{array}
\begin{array}{c}
\overset{2p \text{ variables}}{\overbrace{\phantom{(x_{11}, y_{11}) \cdots (x_{1f}, y_{1f}) \cdots (x_{1p}, y_{1p})}}} \\
\begin{bmatrix}
(x_{11}, y_{11}) & \cdots & (x_{1f}, y_{1f}) & \cdots & (x_{1p}, y_{1p}) \\
\vdots & & \vdots & & \vdots \\
(x_{i1}, y_{i1}) & \cdots & (x_{if}, y_{if}) & \cdots & (x_{ip}, y_{ip}) \\
\vdots & & \vdots & & \vdots \\
(x_{n1}, y_{n1}) & \cdots & (x_{nf}, y_{nf}) & \cdots & (x_{np}, y_{np})
\end{bmatrix}
\end{array}.
$$

04

Results

Decoding Data

	timestamp_gh	mmsi	msg_type	lat	lon	speed	course	heading	ship_type	to_bow	to_stern	to_port	to_starboard
87682	2022-01-03 09:10:33.653	244670800	1	53.660263	14.517508	0.0	275.200012	511.0	70.0	69.0	11.0	4.0	4.0
215612	2022-01-03 09:10:33.653	261004860	1	54.795746	18.415932	0.0	0.000000	511.0	30.0	16.0	8.0	3.0	3.0
251036	2022-01-03 09:10:33.653	261010050	3	53.563034	14.590933	0.0	189.399994	249.0	52.0	15.0	19.0	5.0	4.0
402024	2022-01-03 09:10:33.653	261183730	2	53.428085	14.584202	0.0	360.000000	511.0	80.0	70.0	10.0	3.0	5.0
447536	2022-01-03 09:10:33.653	261185450	2	53.403099	14.605347	0.0	0.000000	511.0	79.0	53.0	12.0	7.0	1.0

Near-miss classification analysis

No.	Type of Encounter	No. of encounters for Fukuto and Imazu threshold
1	Negative encounter (NNE)	4,900
2	Safe encounter (NSE)	7,984
3	Near miss encounters (NNM)	5,870
4	Total encounter (NTE)	18,754
5	Ships involved in NNM	65

Near-miss classification analysis

No.	Type of Encounter	No. of encounters for Fukuto and Imazu threshold
1	Negative encounter (NNE)	3,175,047
2	Safe encounter (NSE)	4,424,891
3	Near miss encounters (NNM)	0
4	Total encounter (NTE)	7,599,938
5	Ships involved in NNM	0

05

Limitations

Limitations

- We were only able to decode 10 GB encoded data of the 373 GB provided.
- We had to analyse the data in chunks so we do not have the possible ship interactions between the chunks
- We only analysed AIS data received between 23rd February 2021 and 4th March 2021.

06

Conclusion

Use of the IALA risk management toolbox course

Use of the IALA risk management toolbox course

References

- Bhattacharjee, S. (2022, September 5). What is Automatic Identification System (AIS)- Types And Working (FAQs). Marine Insight. https://www.marineinsight.com/marine-navigation/automatic-identification-system-ais-integrating-and-identifying-marine-communication-channels/
- IALA-AISM. (n.d.). IALA World-Wide Academy - IALA WWA Academy. https://academy.iala-aism.org/wwa/
- IALA-AISM. (n.d.). About IALA. IALA AISM. https://www.iala-aism.org/about-iala/
- IALA-AISM. (2023, April 5). GH AIS Message Format - IWRAP. IALA AISM. https://www.iala-aism.org/wiki/iwrap/index.php/GH_AIS_Message_Format
- IALA-AISM. (2023, April 7). Welcome to the IWRAP Mk2 Wiki site. IWRAP. https://www.iala-aism.org/wiki/iwrap/index.php/Main_Page
- Prastyasari, F. I., & Shinoda, T. (2020, September). Near miss detection for encountering ships in sunda strait. IOP Conference Series: Earth and Environmental Science, 557, 012039. 10.1088/1755-1315/557/1/012039

References

- Raymond, E. S. (2023, June 24). AIVDM/AIVDO protocol decoding. GitLab. https://gpsd.gitlab.io/gpsd/AIVDM.html
- Richter, L. M. (2022). Welcome to Pyais's documentation! — Pyais 2.1.1 documentation. https://pyais.readthedocs.io/en/latest/
- Sang, L., Yan, X., Wall, A., Wang, J., & Mao, Z. (2016). CPA Calculation Method based on AIS Position Prediction. The Journal of Navigation, 69(9), 1409-1426. 10.1017/S0373463316000229
- Transportation Research Board. (2003). Shipboard Automatic Identification System Displays Meeting the Needs of Mariners -- Special Report 273. https://doi.org/10.17226/10708
- Vestre, A., Bakdi, A., Vanem, E., & Engelhardtsen, Ø. (2021, May 25). AIS-based near-collision database generation and analysis of real collision avoidance manoeuvres. The Journal of Navigation, 74(5), 985–1008. 10.1017/S0373463321000357

Thank You!