SMART INDIA HACKATHON 2024

TITLE PAGE

- **Problem Statement ID –** SIH1655
- **Problem Statement Title-** Detecting oil spills at marine environment using Automatic Identification System (AIS) and satellite datasets
- **Theme-** Smart Automation
- **PS Category-** Software
- **Team ID-** 30343
- **Team Name:** Challengers_warrior

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GOD'S EYE

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Our Approach

AIS Data Preprocessing & Cleaning
AIS Data of vessels is fetched which is passed through various preprocessing steps before feeding it to ML1 model.

Time Series Model (ML1)
Two Sequences of past and present are made consisting of LAT,LON,SOG,COG where ML1 gives a probabilistic output for present timesteps.

Live Monitoring of Anomaly scores
Anomaly Score is calculated from the variations in Predicted and Actual Trajectory. if the score surpass the given threshold , Anomaly is flagged & reported.

Request To API
On flagging an anomaly, a request is sent for the latest SAR image of the ROI to the Sentinel Hub.

SAR Data Preprocessing & Cleaning
The retrieved SAR image is sent through preprocessing. This involves calibration, speckle filtering, and Georeferencing.

Modified DeepLabV3 (ML2)
The processed SAR images are fed into the modified DeepLabV3 which outputs classification score & oil mask for potential oil spills.

Final Report
ML1 alone is capable of flagging various types of anomalies , combining with ML2 reduces False Positives then Final report is presented.

Problem Resolution

Focused Maritime Surveillance: Instead of broad monitoring, we focus only on vessels in distress, making it more efficient and resource-effective

Automated Early Detection: With predictive models, our system automatically identifies atypical vessel behavior, enabling early detection of potential oil spills without human intervention.

Minimized Environmental Impact: mitigating the environmental damage caused by oil spills by early detection.

Innovation & Uniqueness

01
Integration of state-of-the-art time series and image processing models, optimized specifically for maritime surveillance.

02
Fully automated solution, reducing reliance on manual reporting.

03
Easily integrable with existing AIS and satellite architectures.

04
Flexible for detecting other maritime anomalies, such as ship collisions , engine failures , etc.

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TECHNICAL APPROACH

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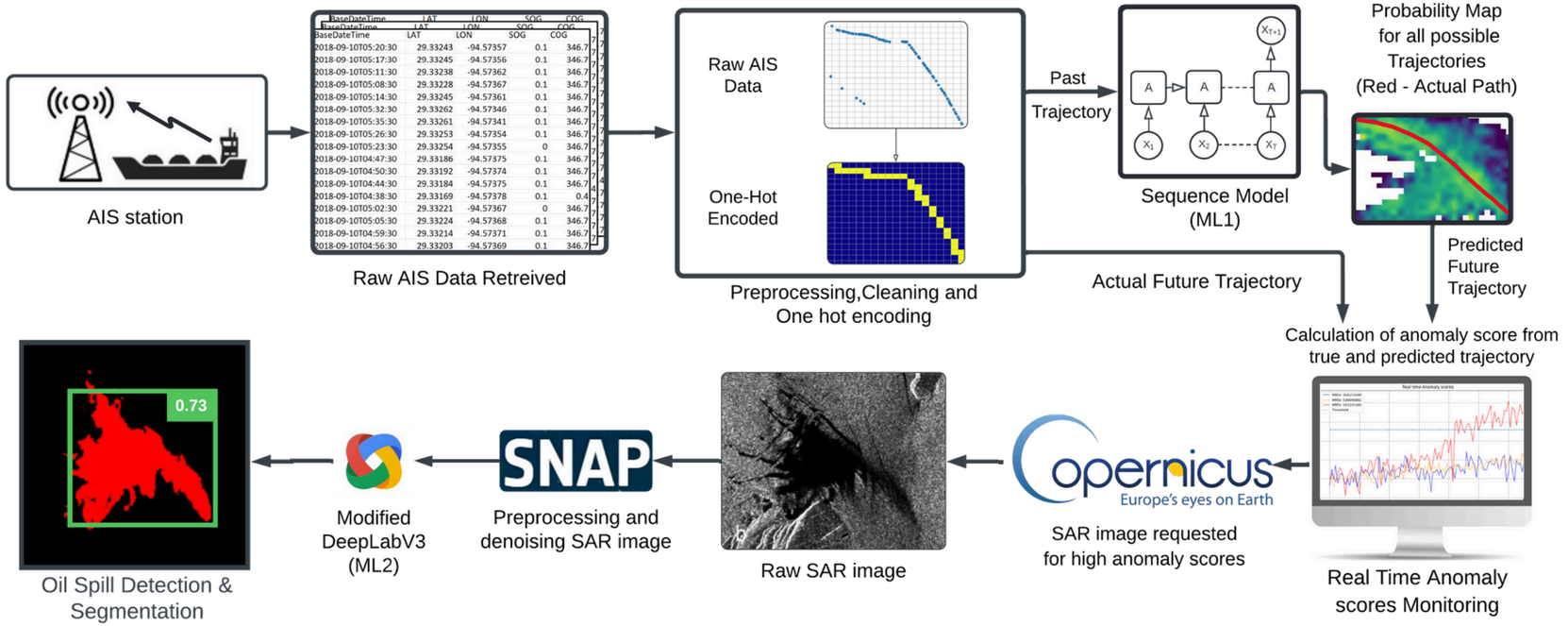
End to End System Workflow



Dataset and API

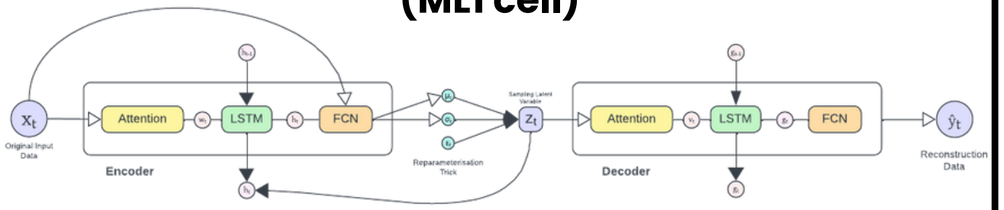
AIS (Automatic Identification Systems)

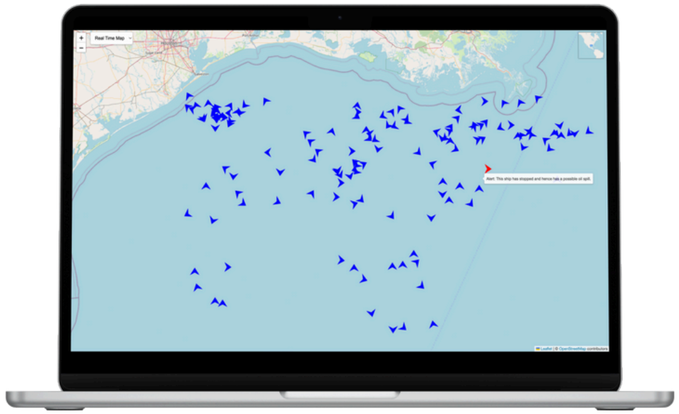
Copernicus

Tech Stack:

- ML : TensorFlow, Flask, PyTorch.
- Web Development: React Js, Leaflet Js,Node Js

'A' is MultiHead-Attention-BLSTM With VAE (ML1 cell)





Leaflet PyTorch ReactJS Flask node JS TensorFlow pandas NumPy matplotlib XGBoost

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FEASIBILITY AND VIABILITY

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Analysis of Feasibility & Viability

01

Technical Feasibility

Most maritime vessels are already equipped with AIS architecture, allowing for easy integration of our model..

02

Scalability

The platform is adaptable to various maritime challenges, including ship collisions and vessel failures ensuring it meets the evolving needs in maritime safety and respond effectively to emerging issues.

03

Financial Viability

By automating oil spill detection and reducing reliance on manual monitoring, our solution significantly cuts operational costs while ensuring continuous monitoring..

04

Market Feasibility

Offering the oil spill detection and monitoring system as a SaaS platform allowing us to produce revenue from organizations seeking ongoing monitoring and analytics, reinforcing market demand for our solution.

Challenges and Solution

Inconsistencies and Tampering in AIS data	Cross referencing with Vessel Monitoring System (VMS) to detect discrepancies
Regional factors limit model adaptability	Implement Domain Generalization based on regional conditions to improve overall performance.
SAR images offer limited coverage and lack detail for precise monitoring.	Hierarchical stacking of low-resolution SAR for early detection, followed by high-resolution SAR for detailed analysis.
Alignment of AIS and SAR due to delays in acquiring latest Satellite data	Collaboration of various Satellites with varying revisit times to ensure timely image acquisition and reduce delays.
Adaptability for Real-World Conditions	Adaptive Monitoring with Feedback Loops and Environmental Data Integration to refine the model continuously

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IMPACTS AND BENEFITS

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Impacts:

Shipping/Oil Companies

- Faster oil spill detection enables quicker enforcement.
- Real-time monitoring of vast maritime zones.
- Data-driven decision-making for interventions and penalties.

Researchers

- Access to rich, real-time datasets for analysing marine pollution patterns
- Opportunities for interdisciplinary collaboration in environmental science and AI

Maritime Authorities

- Improved vessel tracking, reducing risks of illegal dumping.
- Better resource allocation for spill response and environmental protection.

Regulatory Authorities

- Faster oil spill detection enables quicker enforcement.
- Real-time monitoring of vast maritime zones.
- Data-driven decision-making for interventions and penalties.

Environmental Groups

- Early alerts allow quicker advocacy and environmental action.
- Transparent monitoring data to hold companies accountable.

Coastal Communities

- Enhanced protection from environmental and health hazards.
- Preservation of local economies, especially fishing and tourism industries.

General Public

- Increased public awareness and trust in maritime environmental protection.
- Encouragement of sustainable practices and pollution prevention efforts.

Benefits

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RESEARCH AND REFERENCES

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ITOPF OIL SPILL Statistics:

- https://www.itopf.org/fileadmin/uploads/itopf/data/Documents/Company_Lit/Oil_Tanker_Spill_Statistics_2023

Dataset for AIS:

- https://hub.marinecadastre.gov/pages/vesseltraffic

Dataset for segmented SAR Images:

- https://m4d.iti.gr/oil-spill-detection-dataset/
- https://drive.google.com/file/d/1MKBcASK22931kqsUT886n7Ufdz3g_GZ8/view?pli=1

Oil Spill reports:

- https://incidentnews.noaa.gov/browse/date?page=40
- https://www.researchgate.net/publication/360564462_Oil_Spill_Environmental_Risk_Assessment_and_Mapping_in_Coastal_China_Using_Automatic_Identification_System_AIS_Data
- https://www.researchgate.net/publication/357833953_Anomaly_Detection_in_Maritime_AIS_Tracks_A_Review_of_Recent_Approaches
- https://www.ospo.noaa.gov/products/ocean/marinepollution/2018_archive.html

State of the Art Model for AIS anomaly Detection:

- https://www.researchgate.net/publication/373714583_MA-VAE_Multi-head_Attention-based_Variational_Autoencoder_Approach_for_Anomaly_Detection_in_Multivariate_Time-series_Applied_to_Automotive_Endurance_Powertrain_Testing
- Convolutional VRNN for Anomaly Detection: https://arxiv.org/abs/1909.02168

State of the Art Model for Image Segmentation:

- DeepLabV3 for Semantic Image Segmentation: https://arxiv.org/abs/1802.02611
- DeepLabV3 Pytorch Implementation: https://pytorch.org/hub/pytorch_vision_deeplabv3_resnet101/
- Oil Spill Identification from Satellite Images: https://www.mdpi.com/2072-4292/11/15/1762