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Detecting Maritime Anomalies Using LSTM and XGBoost Quantile Regression-Powered Prediction Interval Models and Dynamic Thresholding

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Since October of 2023 Baltic undersea cables have been damaged numerous times, some of these incidents are suspected to be an act of sabotage [1, 3]. Such was the case of the 2024 November 17-18 submarine cut incident, when a bulk carrier, Yi Peng 3, lowered its anchor, dragged it on the sea floor for approximately 160 kilometers and cut a telecommunications cable between Sweden and Lithuania [4]. This case, along with other incidents of cable disruption, illustrates the importance of maritime anomaly detection systems, which would allow for swift and reliable detection and response to irregular vessel behavior. We analyzed the Automatic Identification System (AIS) data of the Yi Peng 3 vessel at the time of the incident. This analysis heavily influenced the proposed approach to maritime anomaly detection. The main finding of the analysis was that the difference between heading and course was much larger than what would be expected normally, under meteorological conditions at the time and place of the incident. Thus, the proposed anomaly detection method revolves around the difference between heading and course. Using both AIS and meteorological data, we trained machine learning models to estimate prediction intervals of this measurement in a future window of 25 minutes. We trained eXtreme Gradient Boosted decision trees (XGBoost) and Long-Short Term Memory (LSTM) neural networks with a quantile loss function, which enables models to produce estimates of the conditional quantiles. This allowed us to obtain prediction intervals easily and subsequently have an anomaly detection mechanism. In this study, the effectiveness of XGBoost and LSTM models at maritime anomaly detection was compared using metrics specific to prediction intervals, such as prediction interval coverage probability (PICP) and prediction interval normalized average width (PINAW). It was determined that LSTM models have a PICP of 97.77 % and PINAW of 0.022, while XGBoost achieved an inferior performance, having a smaller PICP of 94.09 % and an approximately equal PINAW of 0.019. Regarding the actual anomaly detection mechanism, simple prediction interval-based anomaly flagging was deemed as an insufficient approach due to the numerous false positives it produced. To mitigate this problem, we used the Dynamic Thresholding method [2], which enables us to determine the anomaly threshold without previous knowledge of the percentage of anomalous cases within the dataset and can be used for anomaly pruning, which will be expanded upon in further research. Most importantly, the model evaluated Yi Peng 3 AIS and meteorological data, and the anomaly was successfully identified using model output and threshold, obtained from Dynamic Thresholding. In conclusion, we propose an approach to maritime anomaly detection that can flag anomalies with a low false positive rate. The method is shown to be effective at detecting anomalous behavior in the Yi Peng 3 Baltic Sea cable disruption case. However, the set of known anomalies, which could be used for the evaluation of this system, is incredibly small, therefore, reliable ways for generating synthetic anomalous vessel movements will be investigated in further research.

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References

[1] BNS. (2024, 11 20). *Chinese ship under surveillance following Baltic Sea cables damage*. Retrieved from https://www.lrt.lt/en/news-in-english/19/2418936/chinese-ship-under-surveillance-following-baltic-sea-cables-damage

[2] Hundman, K. a. (2018). Detecting Spacecraft Anomalies Using LSTMs and Nonparametric Dynamic Thresholding. *Proceedings of the 24th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining.* ACM. doi:10.1145/3219819.3219845

[3] Lehto, E. (2025, 8 11). *Finland charges Eagle S tanker captain, officers over cable cuts*. Retrieved from Reuters: https://www.reuters.com/markets/commodities/finland-charges-eagle-s-tanker-captain-officers-over-cable-cuts-2025-08-11/

[4] LRT.lt. (2024, 11 28). *Chinese ship suspected of deliberately cutting cables in Baltic Sea – media.* Retrieved from https://www.lrt.lt/en/news-in-english/19/2426033/chinese-ship-suspected-of-deliberately-cutting-cables-in-baltic-sea-media