Confidence and Prediction Intervals Usage in Maritime Traffic Awareness Evaluation Using LSTM Deep Neural Networks

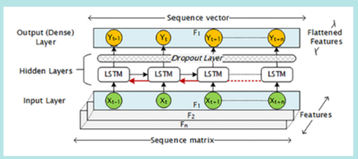
Julius Venskus[1,2], Robertas Jurkus[1,2], Povilas Treigys[1]
[1] Institute of Data Science and Digital Technologies, Vilnius University
[2] Klaipeda University

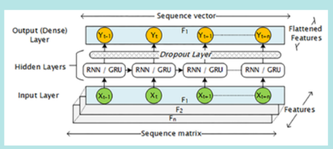
Vilniaus universitetas

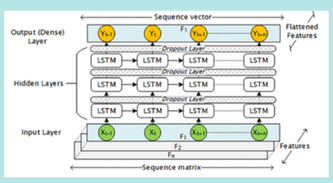
Klaipėdos universitetas

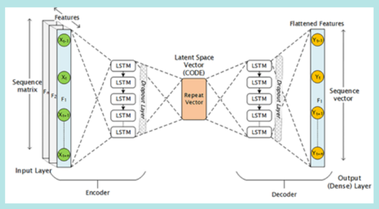
Maritime traffic awareness stands at the crossroads of dynamic oceanic conditions, diverse vessel behaviours, and the intricacies of global trade pathways. The application of Long Short-Term Memory (LSTM) Autoencoder Deep Neural Networks has heralded significant advancements in the realm of maritime traffic prediction, offering a nuanced capability to capture temporal vessel movement patterns and anomalies. Yet, in the vast, unpredictable marine landscape, point predictions, no matter how accurate, can fall short without quantified uncertainties. This presentation ventures into the transformative integration of confidence and prediction intervals within LSTM Autoencoder models, enhancing maritime prediction reliability and robustness. Initially, we shed light on the unique challenges that maritime traffic prediction confronts, emphasising the nonlinearities and temporal dependencies of vessel movement data. The LSTM architecture, inherently suitable for sequence-based data, provides a foundational base for accurate trajectory predictions. Building on this, our advanced model not only captures and reconstructs vessel movement sequences but also estimates the associated uncertainties by generating confidence and prediction intervals. Automated Identification System (AIS) data collected in the Baltic Sea region is used for the evaluation, underscoring the model's prowess in offering a probabilistic view of vessel movements. By presenting both predicted trajectories and their corresponding intervals, stakeholders can assess the potential variability and risks in vessel paths, facilitating enhanced decision-making, from collision avoidance manoeuvres to port docking priorities. Through real-world case studies, authors delineate instances where the integration of prediction intervals can dramatically shape operational and safety decisions, underscoring their indispensable value in maritime traffic awareness. In conclusion, our presentation shows the vital role of confidence and prediction intervals in LSTM neural network models, ushering in a paradigm shift towards uncertainty-aware, resilient maritime operations by evaluating collision likelihood.

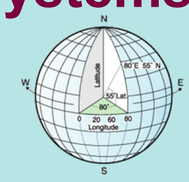
Explored different RNN network architectures; different coordinate systems

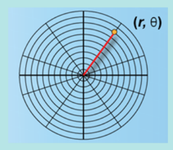


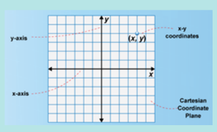




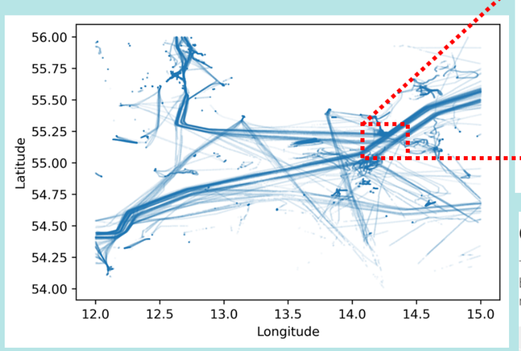


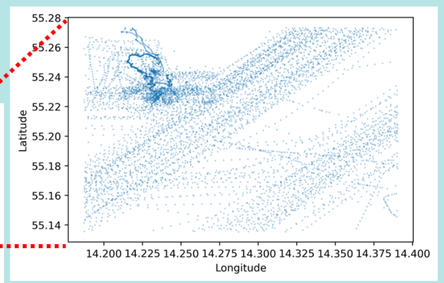


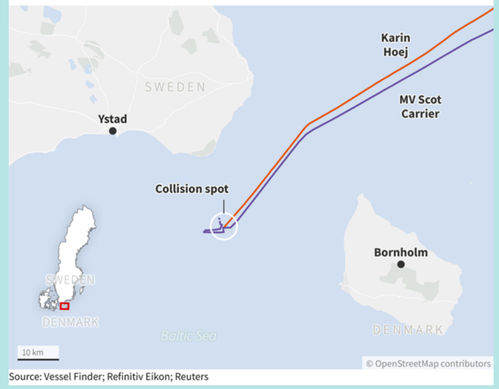




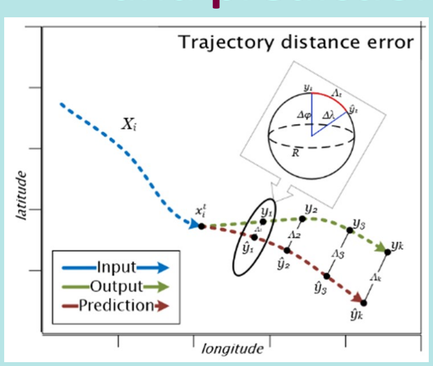
Real case accident analysis

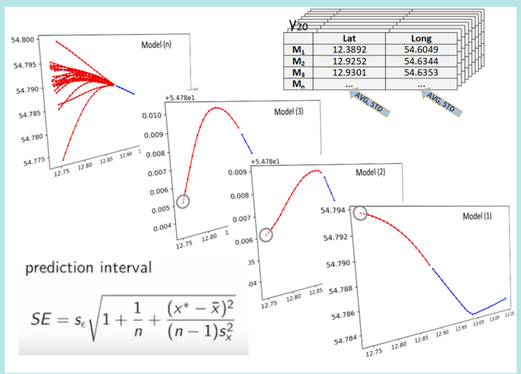






Trajectory error evaluetion and prediction interval definition





Prediction interval intersections for collision forecast evaluation