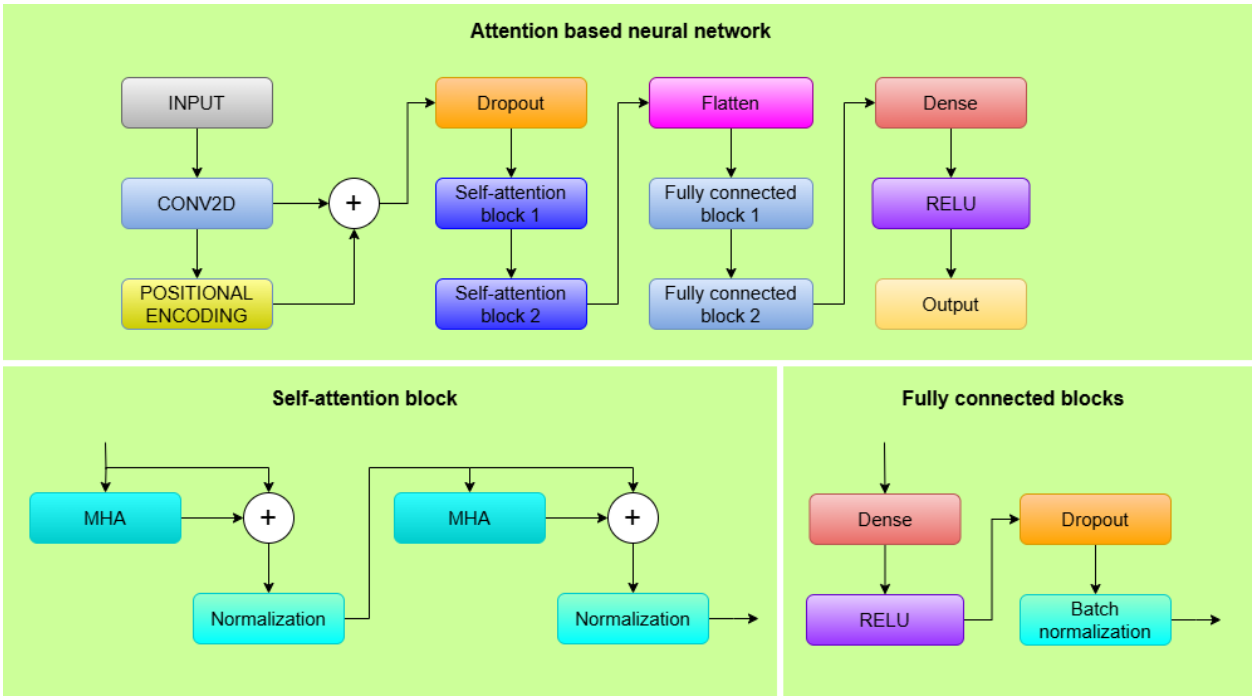
Experiments and actions on the pilot projects 3 until 30.06.2023

Autonomous Shipping Technology



CHALLENGE! To develop advanced technologies to enhance ship safety and navigation by estimating sea states from ship movements.

HOW? Leveraging machine learning (ML) and deep learning (DL) architectures with ship movements (roll, pitch, and heave).

WHY? Encountering adverse weather conditions while navigating can pose significant risks, affecting both the ship's cargo and its crew's safety.

FINAL RESULT→ This project successfully developed innovative deep learning models for sea state estimation and recognition.

GOALS FOR INNO2MARE PROJECT: To integrate AI into the development of a new sea state-estimation and classification algorithm for cargo ships.

Progress

Experiments and actions on the pilot project so far:

1. **Machine learning approach for sea state estimation**

The project compared both original and enhanced versions of multiple existing neural network architectures to estimate sea states from ship movements using a reduced set of 3 degrees of freedom (DOFs). Competing convolutional neural network (CNN) for regression (CNN-REG), Multivariate Long Short-Term Memory CNN (MLSTM-CNN), and Sliding Puzzle Neural Network (SP-NN) models were compared to the newly proposed attention-based neural network (AT-NN), incorporating self-attention mechanisms to

better understand interactions within time-series data. Each architecture was optimized for performance metrics like Mean Squared Error (MSE) and Mean Absolute Error (MAE). The AT-NN model outperformed others with significant reductions in MSE and MAE.

This stage produced two key findings:

– the AT-NN MSE was up to 87% lower than for the original models and 13% for the enhanced versions

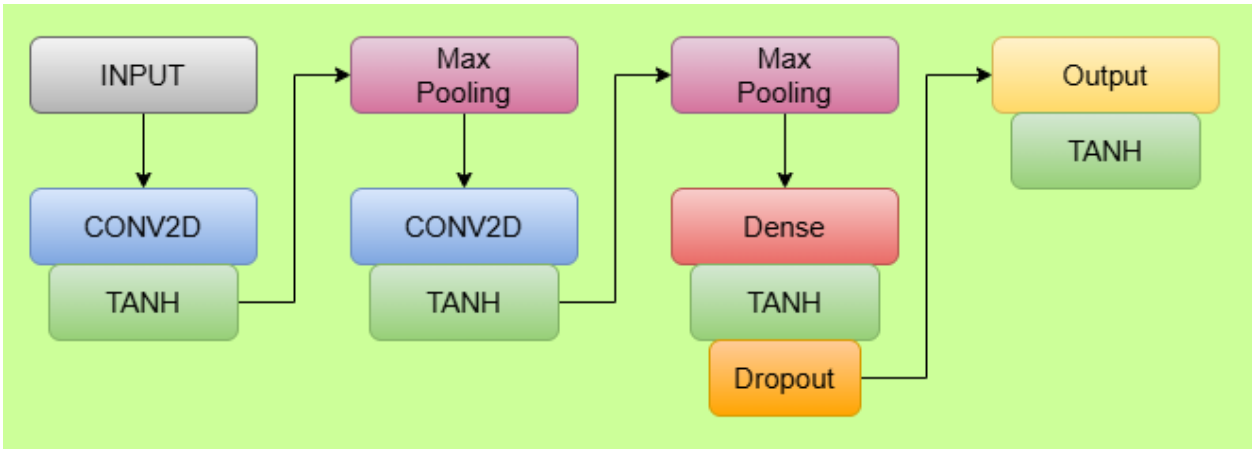
– MAE reductions were up to 68% and 12%, respectively

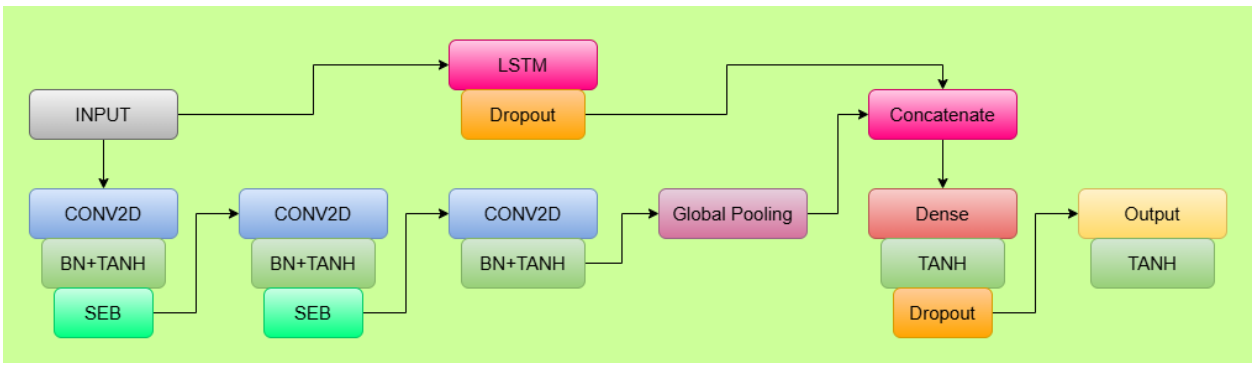
2. Conclusion and future directions

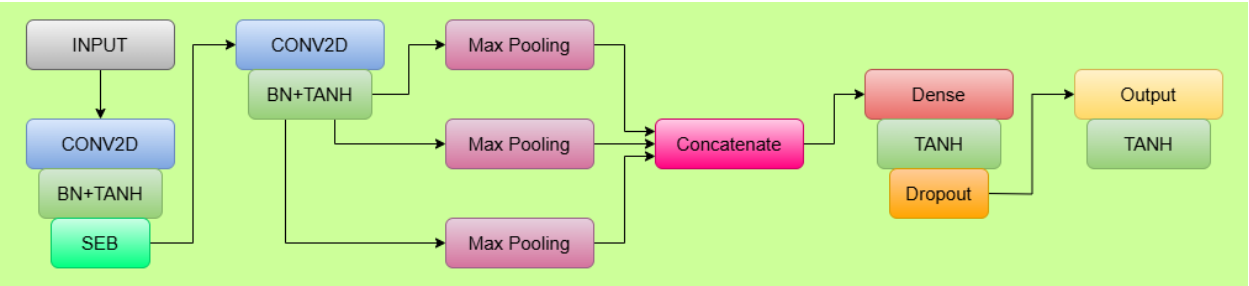
The ML approach for sea state estimation presented in this project has demonstrated remarkable potential. Even with a reduced dataset utilizing only 3 DOFs, the AT-NN maintained superior performance. By reducing input data requirements while enhancing prediction accuracy, it paves the way for practical and scalable applications in autonomous shipping technologies.

Below are the key future research steps:

- **Additional DOFs and Wave Directions**: Incorporating 6-DOF data and estimating the complete wave directional spectrum for broader applicability.
- **Evaluating Ship Characteristics:** The susceptibility of a ship to hazardous conditions depends on various factors, including its stability, hull geometry, size, and velocity.







Publication

Selimović, D.; Hržić, F.; Prpić-Oršić, J.; Lerga, J.: *Estimation of Sea State Parameters from Ship Motion Responses Using Attention-based Neural Networks*, Ocean Engineering, 2023, vol. 281, 114915.

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