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Integrating Environmental Forecasts and Ship Motion Analysis for Predictive Modelling of Motion Sickness in Maritime Operations

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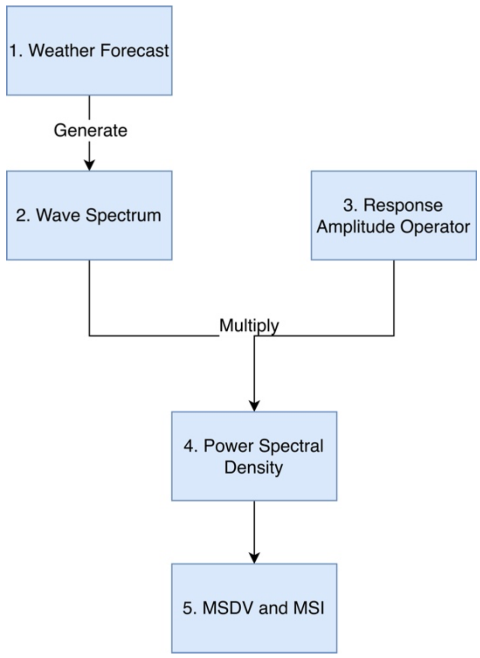
ABSTRACT

Predicting ship motion and its impacts on Motion Sickness Dose Value (MSDV) and Motion Sickness Incidence (MSI) is critical for advancing maritime safety, crew wellbeing, and operational efficiency. These predictions, as illustrated in the figure, help mitigate human discomfort and improve decision-making in maritime operations (Cepowski, 2012).



High-resolution weather models, such as the Integrated Forecasting System (IFS) from the European Centre for Medium-Range Weather Forecasts and the Global Forecast System (GFS) from the National Oceanic and Atmospheric Administration, enable detailed wave spectrum generation (Step 1: Weather Forecast). Spectral models, including Pierson-Moskowitz and JONSWAP, describe ocean wave energy distributions across frequencies, providing insights into evolving sea states (Step 2: Wave Spectrum). Response Amplitude Operators (RAOs) quantify vessel response to wave-induced motions, enabling ship motion predictions across six degrees of freedom (Step 3: Response Amplitude Operator) (Turan et al., 2009). While these tools are well-established, there remains a lack of a comprehensive framework that integrates environmental forecasts, ship motion dynamics, and human-centric metrics such as MSDV and MSI (Bielicki, S., 2021)

This study addresses this gap by developing a predictive framework, shown in the figure, that integrates weather forecasts, wave spectra, RAOs, and Power Spectral Density (PSD) analyses (Step 4: Power Spectral Density). RAOs are combined with wave spectra to generate PSD curves, analyzing motion energy distribution across frequencies. MSDV is calculated by integrating frequency-weighted PSDs to capture root mean square (RMS) motion signals correlating with human discomfort (Cepowski, 2012), while MSI predictions utilize cumulative distribution functions to assess probabilities of motion-induced discomfort and (Bielicki, S., 2021).
The results demonstrate enhanced prediction accuracy for MSDV and MSI, providing quantitative assessments of motion exposure's effects on passenger comfort and operational performance (Turan et al., 2009). The findings have significant implications for maritime safety, operational efficiency, and crew wellbeing, advancing the field of motion sickness prediction and its applications.

References

Cepowski, T., 2012. The prediction of the Motion Sickness Incidence index at the initial design stage. Zeszyty Naukowe/Akademia Morska w Szczecinie, (31 (103)), pp.45-48.

Turan, O., Verveniotis, C. and Khalid, H., 2009. Motion sickness onboard ships: subjective vertical theory and its application to full-scale trials. Journal of marine science and technology, 14, pp.409-416.

Bielicki, S., 2021. Prediction of ship motions in irregular waves based on response amplitude operators evaluated experimentally in noise waves. Polish Maritime Research, 28, pp.16-27.