Inverse Ocean Wave Estimation from FPSO Motions by Artificial Neural Network

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ABSTRACT

This study proposes an artificial neural network (ANN) model to inversely estimate sea states from the motion signals of floating structures measured on board. A generic moored FPSO (floating production storage and offloading) is modeled and 6DOF-motion time-series data are generated by dynamic simulations under different wave/wind/current conditions. Then, the statistical data are obtained such as mean and standard deviation to be used as inputs in the ANN model. Then, significant wave height, peak period, and wave direction are estimated by the ANN model. The results demonstrate that the proposed ANN model successfully estimates sea states.

KEY WORDS: Sea-state estimation; Platform motion; Artificial neural networks; FPSO; Significant wave height, Peak period, Wave direction.

INTRODUCTION

For effective and secure onboard operations, environmental conditions are needed. One of the most important elements determining a platform's stability is the state of the external waves. For onboard decision support and operational guidance, the continuous sea state information around an FPSO (floating production storage and offloading) is essential. The safety of the activities can be improved through sea-state estimation. Nevertheless, accurate sea state data collection is difficult and is typically carried out utilizing satellite data, wave rider buoys, lidar, or wave radars. However, each of these approaches has its own drawbacks and difficulties (Scholcz and Mak 2020).

Floating wave buoys are now the main method for gathering precise statistics on ocean waves around floating structures. Since the system is sensitive to the impacts of rainfall, the majority of those devices require laborious installation and difficult management, and quality may be affected by significant vessel motions and local climatic conditions. In addition, in many cases, the locations of floating platforms are tens or hundreds of kilometers away from the wave buoys, so accurate sea-state estimation on the exact platform locations is challenging and requires expensive equipment such as Lidar.

A floating platform or ship can also be regarded as a giant wave buoy because, like a wave buoy, its motions reflect the conditions of the sea. Most marine vessels or platforms in use today have enough sensors to measure six-degree-of-freedom (6DOF) motions (Han, Li et al. 2022). Utilizing a motion sensor is a cost-effective solution compared with expensive Lidar applications. However, sea-state estimation from ship motions is an inverse problem, which means that there is no unique solution to a sea state from motions. In addition, due to the vessel's operation and the varying correlation between waves and floater motions under loading and unloading conditions, estimating the sea condition based on floater motions is difficult.

In this regard, this research proposes an artificial neural network (ANN) model to estimate sea states from FPSO motions. Recently, ANN models have successfully been applied as a monitoring algorithm for various Ocean Engineering problems (Kwon, Jin et al. 2020, Kwon, Jin et al. 2022, Sivaprasad, Lekkala et al. 2023). Floating structure motions can also be successfully used by machine learning to inversely estimate wave conditions since many floating structures already have on-board motion measurement devices. Duz et al. (2019) use ship motion time series data which allows the use of local phase differences.