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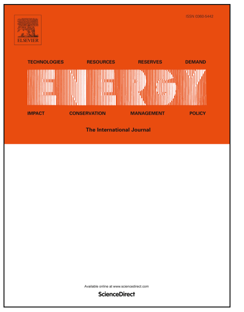

Maximization of energy absorption for a wave energy converter using the deep machine learning

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Maximization of energy absorption for a wave energy converter using the deep machine learning

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Abstract

A controller is usually used to maximize the energy absorption of wave energy converter. Despite the development of various control strategies, the practical implementation of wave energy control is still difficult since the control inputs are the future wave forces. In this work, the artificial intelligence technique is adopted to tackle this problem. A multi-layer artificial neural network is developed and trained by the deep machine learning algorithm to forecast the short-term wave forces. The model predictive control strategy is used to implement real-time latching control action to a heaving point-absorber. Simulation results show that the average energy absorption is increased substantially with the controller. Since the future wave forces are predicted, the controller is applicable to a full-scale wave energy converter in practice. Further analysis indicates that the prediction error has a negative effect on the control performance, leading to the reduction of energy absorption.

Keywords: wave energy converter; wave energy control; energy absorption; neural network; deep machine learning; wave force prediction.

1. Introduction

To keep up with the growth of global energy demand, various energy systems have been developed to extract power from marine energy sources (offshore wind, ocean waves, tide, etc) [1-3]. Compared with other marine energy resources, wave energy is a kind of resource with high power density and all-day availability. Owing to these advantages, wave energy is regarded as a prospective solution to the sustainable generation of power. The device used to harvest energy from ocean waves is called the wave energy converter (WEC). Li et al. [4] showed the power output of an oscillating-body WEC installed on a spar-type floating wind turbine. He et al. [5] utilized a floater breakwater to harvest energy from the waves. Experimental study of the concept was performed. Falcao and Henriques [6] presented a review on the oscillating-water-column WEC. Stansby et al. [7] examined the dynamics of multi-float WEC concept M4.

Although a set of WEC concepts have been developed, the energy harvesting efficiency is still not satisfactory, especially in the off-resonance state. One of the solutions is the usage of a non-linear power take-off (PTO) system. Zhang and Yang [8] showed that a PTO system with nonlinear spring could harvest more energy in random waves. Xiao et al. [9] investigated the power capture of an