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

Liang Li, Zhiming Yuan, Yan Gao



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3 Liang Li, Zhiming Yuan*, Yan Gao

4 *Department of Naval Architecture, Ocean and Marine Engineering, University of Strathclyde, 100 Montrose Street,*
5 *Glasgow, G4 0LZ, UK*

6 **Corresponding author: zhiming.yuan@strath.ac.uk.*

7 Abstract

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

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

20 1. Introduction

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

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

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