Long-Short Term Memory Based TALOS Wave Energy Converter Power Output Prediction with Numerical Modelling

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ABSTRACT

Wave energy shows potential to provide electricity in a renewable manner. The TALOS WEC (Wave Energy Converter) is a unique design with six PTO (Power Take-Off) elements to provide six Degrees of Freedom (DOFs), which is potentially able to harvest energy more efficiently than traditional single-DOF devices. As a step towards its optimisation and control, a power prediction model is developed, using the wave elevation and motions of the WEC to predict the power output of each PTO. The results show that using LSTM (Long-Short Term Memory) has a higher prediction accuracy than the other approaches considered.

KEY WORDS: TALOS; WEC; power prediction; machine learning; LSTM

INTRODUCTION

Much research has been done on energy harvesting technologies over the past few decades, in part due to the incoming energy crisis. As a type of renewable energy, ocean waves provide significant energy via a sustainable and reliable approach. As a result, many different types of WECs have been designed and tested to produce clean and renewable energy (Li et al., 2012). Examples include Lancaster University’s PS Frog (Taylor et al., 2002; McCabe et al., 2006), AquaBuOy (AquaBuOy, 2016), and Powerbuoy (Powerbuoy, 2016).

In general, WECs can be categorised as point absorbers, oscillating water columns, terminators, oscillating wave surge converters, attenuators, and submersed pressure differential devices (Aggidis and Taylor, 2017; Darwish and Aggidis, 2022). The majority of WECs are single-DOF devices, which means they could only extract energy from one direction of motion. Based on the single-DOF method, prototypes have been designed such as the Carnegie Wave Energy Limited prototypes (Wave Hub, 2016), the Archimedes Wave Swing (AWS Ocean, 2016), Oregon Limited’s multi-resonant chamber (Orecon, 2009), and Salter’s Duck (Salter, 1974). However, the kinetic power contained in the waves is in multiple directions. In hydrodynamic analysis, the waves have yaw, roll, and pitch motions in heave, surge, and sway axes, respectively. In total, there are six degrees of freedom in WECs that would be affected by the waves. Theoretically, if the device can extract energy from multiple DOFs, more energy can be thus generated.

Despite of the majority designs being single-DOF, few multi-DOF WECs have been developed to date. One of the most famous designs is Pelamis, which is a snake shape device with several tubes that are connected by hydraulic rams. The electricity is generated from the hydraulic rams that connect the moving tubes. Pelamis prototypes have been deployed in Portugal and Scotland and fed electricity in national grids (Boyle and Duckers, 2012).

Compared with single-DOF devices, multi-DOF WECs have seen much less research and prototype design. Development of Pelamis, for example, was cancelled because the company went into administration after being unable to secure the level of additional funding required for the further development of their technology (Wave power firm Pelamis calls in administrators, 2014). NHP-WEC (Novel High-performance Wave Energy Converter) is an ongoing project that aims to design a novel multi-DOF point absorber style WEC, called TALOS, built as a 1/100th scale representation, with a solid outer hull containing all the moving parts. These include a ball mass and dampers (PTOs) that connect the ball and the hull as shown in Fig. 1.

During the development of the prototype, ocean uncertainties threaten the reliability and stability of the ocean energy system, especially for WECs (Sanchez et al., 2018). Hence, it is necessary to forecast ocean