A Predictive Model for Oscillating Water Column Wave Energy Converters Based on Machine Learning

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Introduction

In South Korea, the Yongsu Wave Power Plant was constructed in 2014 as a fixed OWC wave energy converter 1.2 km offshore in front of Yongsu-ri, Hangyeong-myeon, Jeju-si, and is now preparing for pilot operation. The electric power generated from the wave energy of OWC is generally in the range of 60~500 kW, and the Yongsu Wave Power Plant is being tested with the goal of 500 kW.

The pressure prediction of the chamber is not only a most direct variable in improving the energy efficiency, but also necessary to control the breakdown problem under a large pressure, which is a big issue in the power generator of the Yongsu Wave Power Plant.

In this study, we aim to maximize power generation and prevent breakdown by predicting the pressure of the chamber. We design a prediction model by applying data preprocessing and machine learning including data correlation analysis based on the collected data, and verify the validity of the pressure prediction by evaluating the learning model.

Methodologies

To develop a learning model based on real data, we acquired sensor data produced from the external waves of the OWC wave power generation system under pilot operation now and the sensor data generated from the OWC wave height meter. After data preprocessing such as filtering, the data were classified into training set and test set and used to develop a learning model.

To build a data analysis model, a series of processes required for machine learning such as data integration, conversion, analysis and visualization were performed using the open source-based KNIME platform and Tensorflow. To verify the machine learning algorithm, DT (Decision Tree), RF (Random Forest), SVM, and RNN algorithms were applied and tested using the machine learning framework Tensorflow. Then we proposed the most effective technique for OWC prediction and developed a learning model that can be used without modifying the core techniques even when the sensor type, position, and data are changed in the future.

Tables

Table 1. KNIME

Features	Details
Openness	Easy to integrate with various software applications such as Hadoop, Spark, R, Python, JAVA, SPSS, and SAS
Big data processing	In-database processing of general-purpose DBMS, data handling and machine learning by in-Hadoop processing can be performed.
Scalable programs	Customized dialogs can be produced by supporting languages and graphics such as R and Python.
Various data access and handling	Supports multi-purpose DBMS such as MySQL, Oracle, and Teradata, and provides various types data source access and handling functions including Excel, XML, Twitter, Google, and Facebook.
Various predictive analytics	Supports statistics analysis, data mining and machine learning algorithms. It is possible to perform the machine learning algorithms of R and WEKA in Visual programming method.

Figures

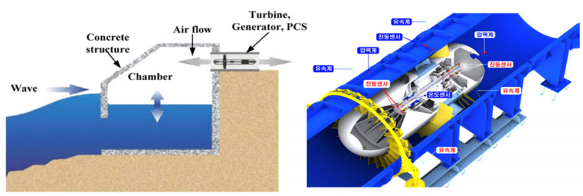

Figure 1. OWC wave energy converter and air turbine

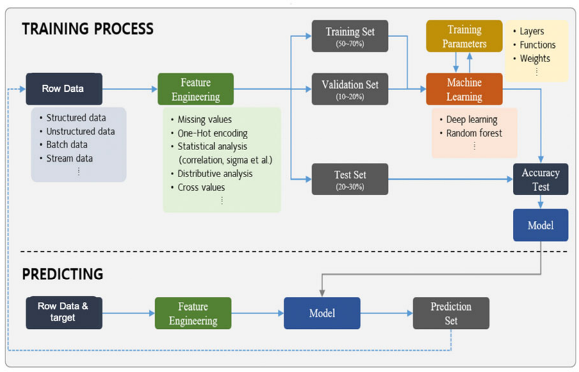

Figure. 2 Development process of pressure predictive model based on machine learning in OWC

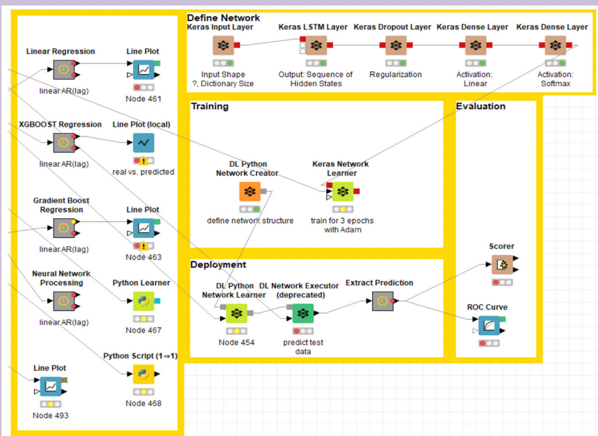

Figure. 3 Proposed OWC pressure prediction model

Conclusion

In this study, we applied machine learning-based prediction technology, which is an element technology of digital twin, based on the IoT sensor data of the Yongsu Wave Power Plant, which is currently in operation, and verified its validity. Regarding the wave power plant, we defined meaningful data by multiple parameters such as wave height data, and OWC sensor data, and analyzed correlations from these parameters. Then a methodology for predicting the desired information was researched through this process. Features appropriate for machine learning model were derived through feature engineering based on a raw dataset, and a model with a high score was selected after training the selected dataset using various machine learning models. Through this study, improved operation efficiency could be expected by predicting the OWC pressure, which is closely related to the generation amount and failure of the wave energy converter. In addition, the validity of the machine learning technology required for smart operation through the digital twin of the wave power generation system could be verified.