Listening to your cable with Artificial Intelligence for Asset Monitoring

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ABSTRACT

This paper describes a novel approach for detecting sub-sea power cable burial status using Distributed Acoustic Sensing (DAS) and machine learning — specifically artificial neural networks. Currently, DAS has been used predominantly to monitor power cables for faults and acoustic disturbances. With advancements in the quality of data captured by the AP Sensing DAS system, it is possible with feature processing to train a neural network to determine the burial status of a cable. This paper will explore such a case and the validity of the results from the experiment.

KEYWORDS

DAS; Neural Networks; AI; Reburial; Subsea; Power Cable.

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INTRODUCTION

Damage to subsea power cables creates significant impacts on revenue for the cable owner's business and for those affected by the loss of service. Repairs and cable monitoring for fault location can be a timely process causing further cost and loss of revenue. Typically, Remotely Operated underwater Vehicles (ROVs) are used to survey subsea cables. These have a high cost and cannot provide continuous monitoring of an entire cable. Distributed Acoustic Sensing (DAS) systems provide solutions for cable fault monitoring and has been successfully used to continuously monitor cables for faults and disturbances.

Developments in data processing and pattern recognition systems are happening at an ever-increasing rate. Consequently, sophisticated algorithms and artificial intelligence have become more accessible and less exclusive to the realm of academia and are being taken up and used successfully in industry for enhancing output, classification and predictive modelling. The DAS produces large amounts of valuable data which can be interpreted in many different ways, therefore it was logical to use advanced data analysis techniques and apply them to the DAS data to extract crucial patterns which could provide invaluable insight.

DAS

Distributed Acoustic Sensors have been used for a large number of applications from intrusion detection to cable fault and leak detection, as they give measurement of acoustic signals without interference from electromagnetic radiation. In recent research it has also been shown that temperature changes can be measured in a phase-sensitive optical systems such as the AP Sensing Distributed Acoustic Sensor [1]. Current DAS Systems have been shown to be effective up to 70km making them viable for large scale deployment.

By exploiting this information, patterns relating to subsea cables can be explored in more depth than previously done before.

ARTIFICIAL NEURAL NETWORKS

Neural networks are at the forefront of current machine learning technology. These are mathematical models designed to replicate the learning process of the human brain. They are heavily used in the process of identifying underlying patterns in data which can then be exploited and automated [2]. The basic structure of an Artificial Neural Network (ANN) is shown in **Fig. 1**. Models contain an input layer of nodes (shown on the left) that are features extracted from the data. Each adjacent layer in an ANN is fully inter-connected with the nodes in adjacent layers, and the strength of each connection is determined by the weight, W_{xx}. Each node has an activation function, *f*, which calculates the output from the node based on the weighted sum of the inputs from the connected nodes. The weights are calculated during the model's training via back propagation (minimising the error of the model). The direction of the data flow is shown by the directional arrows.

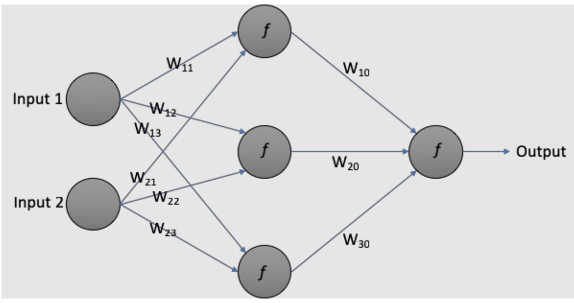

Fig. 1: Structure and data flow of a basic ANN, demonstrating the weights (W_{xx}) and activation functions (*f*).

The complex structure of these models makes them extremely efficient at identifying patterns in data, which can then be exploited and automated [4].

CABLE REBURIAL

Subsea cable systems are susceptible to the environmental changes such as wave motion, natural disasters, and human activities such as anchoring and fishing [5]. Burying the cable not only gives stability to its physical location but also provides a safer environment from various threats. Therefore, it can be critical to know the cable burial status. Currently this inspection is carried out by ROVs with magnetic or visual sensors, making the evaluation of cable status costly in both time and