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APPLICATION OF SUPERVISED LEARNING AND UNSUPERVISED LEARNING IN THE CLASSIFICATION OF GEAR PITTING FAULTS

Xueyi Li
School of Mechanical Engineering and Automation, Northeastern University, Shenyang, Liaoning, China
e-mail: lixueyineu@gmail.com

Gear pitting failure is one of the primary failure modes of gears. With the increasing application of machine learning technology, more and more learning methods are applied in the diagnosis of gear pitting faults. This paper analyzes two main methods of deep learning. In this paper, the supervised learning algorithm represented by inception structure and the unsupervised learning algorithm represented by autoencoder is taken as an example to classify and identify the pitting conditions of different gears in the experiment. The classification results of gear pitting faults are analyzed and compared. Compare the advantages and disadvantages of the two algorithms and make reasonable choices for different situations.

Tooth surface pitting is one of the most common forms of failure in mechanical transmission. It can be seen from many literature investigations that the occurrence and development of pitting corrosion is a long-term periodic stress concentration. From the beginning of the pitting to the obvious tooth surface exfoliation, it has experienced two development stages, one is early pitting, mostly due to meshing. In the early stage, there will be micro-protrusions on the tooth surface, and pitting will occur due to large stress, but most pitting will disappear after a period of running; second is extended pitting, based on early pitting, long-term single and double teeth under the impact of alternating meshing, a relatively severe damage occurs at a position close to the pitch line. Tooth surface pitting is the flaking of the tooth surface due to fatigue. Although it is difficult to find in the early stage and has no obvious influence on the normal operation of the equipment, the more serious gear failures such as cracks and fractures are developed from pitting corrosion. If the development of pitting corrosion is not detected and prevented in time, it may cause more serious damage to the tooth surface, accelerate the development of gear pitting, and even lead to tooth fracture. Therefore, the timely discovery and avoidance in the early stage is extremely important for the safety of the equipment and the extension of the service life of the equipment and the maintenance of the accuracy of the equipment.

Deep learning is currently the hottest branch in the field of machine learning. Deep learning is proposed to solve the problem of difficulty in extracting deep features of data. When the artificial neural network deals with simple problems, only two layers of neurons may be needed. One layer is responsible for inputting the signal and processing the signal and then passing it to another layer, and the other layer is responsible for outputting the signal. However, in the deep network, it is not a simple two-layer structure. There are many hidden layers composed of linear or nonlinear elements between the input layer and the output layer to further process the transmitted data. So far, various network structures for deep learning, such as Convolutional Neural Networks (CNN), Deep Belief Network (DBN), and AutoEncoder (AE) etc., have been widely applied to computer vision and speech. Identification, bioinformatics and other areas, and there are indications that deep learning network models have performed well in these areas.

Supervised learning, also known as teacher learning, is an important learning method in three forms of machine learning. It is also the first basic algorithm theory in machine learning. It is the foundation of other learning algorithms. In the supervised learning, the categories of all samples are known, and the functions or parameters of the classifier can be inferred or adjusted by these labeled samples, which is the task of the machine learning. Regardless of the solution to the problem, the essence of the supervised learning algorithm is to solve the correspondence between the learning training data (input) and the category (output) and apply the relationship obtained from the known data to the unknown data. The Inception module is a

hybrid model that is a modification of the convolutional layer that extends the convolution operation in width and depth. In traditional convolutional neural networks, convolutional layers are stacked together, and multiple convolutional layers form a complex nonlinear simulator. All convolution kernels in the same convolutional layer have the same hyperparameter, which means that the features that can be extracted by each layer are invariant in dimension. The Inception module contains convolution operations, but unlike traditional convolutional neural networks, multiple paths can be set in the module, each path can be a different operation, the same operation different kernel sizes and strides can be set.

Unsupervised learning is a learning algorithm that is not subject to category constraints. It does not require prior knowledge to guide, but through continuous self-awareness, self-consolidation, and self-induction to learn. In the field of machine learning and deep learning, it is different from supervised learning. The training set for unsupervised learning is not labeled. It mainly includes clustering, principal component analysis dimensionality reduction, generative adversarial networks and autoencoder. The autoencoder is a neural network that contains an input layer, a hidden layer, and an output reconstruction layer. Its main meaning is that the output layer reconstructs the input information so that the output is as equal as possible to the input, including the encoding and decoding processes. The sparse autoencoder increases the sparsity constraint on the activation of the hidden layer neural unit so that most of the hidden layer neural units are inactive. If the output of the hidden layer neuron is close to 1, it is considered to be activated, and when the output is close to 0, it is considered to be constrained, increasing the utilization of the neurons of the autoencoder, making the hidden layer node most of the time Inactive.

The results of processing the gears with different pitting faults indicate that the supervised learning represented by the inception structure or the unsupervised learning represented by the autoencoder structure can obtain the classification results of the pitting faults of the ideal gears. It can be seen from the results that supervised learning requires less data on training data than unsupervised learning, but requires a large amount of tagged data to participate in training. In contrast, unsupervised learning does not require a large amount of tagged data to participate in the training but requires a large amount of training set data to participate in the training. For the case of more classification, it is more suitable to use unsupervised learning, because in unsupervised learning, the deep learning algorithm can learn deep data rules, such as the low to high according to the severity of gear pitting.

In summary, for the classification problem of gear pitting fault detection, in the case of relatively few data and sufficient labels, it is better to choose the supervised learning algorithm represented by inception, etc. In the case that the training set has a large amount of data. The unsupervised learning algorithm represented by autoencoder can be preferentially selected. The parameters can be adjusted to achieve the purpose of letting the neural network learn the deep trend, and the visual data can be used to verify whether the classification trend is consistent with the real situation.

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ВЛИЯНИЕ ЭЛЕКТРИЧЕСКИХ РЕЖИМОВ ЭЛЕКТРОЛИТНО-ПЛАЗМЕННОЙ ОБРАБОТКИ НА КАЧЕСТВО ПОЛИРОВАНИЯ ТИТАНА И НИОБИЯ

Алексеев Ю.Г, Королёв А.Ю., Паршуто А.Э., Нисс В.С., Будницкий А.С., Янович В.А.
Белорусский национальный технический университет

Abstract. *Fundamentally new electrolyte-plasma treatment modes developed by us for the purpose of polishing and cleaning products from titanium and niobium alloys using simple electrolytes based on an aqueous solution of ammonium fluoride, providing a significant increase in surface quality with high reflectivity. The paper presents the results of a study of the influence of the electric modes of the process of electrolytic-plasma polishing of titanium and niobium on the surface quality.*