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DEEP LEARNING-BASED FAULT DIAGNOSIS IN ROTATING MACHINERY

Rotating machinery comprises a broad class of mechanical components which often plays a critical role in many mechanical systems used in manufacturing, automotive, aerospace and other industries. Since rotating elements are commonly exposed to heavy loads they are a subject to wear and tear. Tough working conditions can subsequently lead to failures resulting in a loss of performance, a critical damage or safety issues.

In order to inspect a rotating component for a failure and detect its root cause a process of a fault diagnosis is used. One of the most rapidly developing techniques of a fault diagnosis is the usage of deep learning which allows to increase performance and accuracy of a process of fault detection. This work examines different methods of deep learning with its application to fault diagnosis in rotating machinery.

Non-intelligent methods of fault diagnosis in rotating machinery are based on signal processing techniques. These methods include approaches such as wavelet transform, adaptive decomposition, empirical mode composition, local mean decomposition and others. Traditional methods have such advantages as high interpretability, simplicity and robustness.

Since non-intelligent methods heavily rely on human knowledge and expertise, machine learning techniques are often used instead. These techniques include Bayesian classifier, support vector machine, k-nearest neighbors and artificial neural networks. Machine learning techniques allow to achieve high

adaptability, accuracy, as well as high classification and recognition capabilities. Among deep learning techniques convolutional neural networks (CNNs) and recurrent neural networks (RNNs) are widely used.

CNNs are mainly used for image recognition. Their main advantages are powerful feature extraction capability and high flexibility. CNNs thus can be used in fault diagnosis as a feature extractor for raw signal, preserving as much useful information as needed, or a classifier with multidimensional processed data. For example, the authors of [1] used CNN as a feature extractor and SVM as a fault classifier. This method outperformed other approaches which used traditional feature extraction techniques. Another usage of CNN in fault diagnosis can be observed in [2] where authors demonstrated that the accuracy of a CNN-based fault diagnosis method, which uses thermal image data, is significantly better than the accuracy of traditional signal-based methods.

RNNs are used for processing one-dimensional sequential data, such as texts and time-series signals. This advantage makes them well-suited for analyzing vibration signals. Due to the recurrent structure, RNNs have the ability to learn from past inputs and thus can explore temporal patterns in signals. Since simple RNNs can learn only short sequences of data, the long short-term memory (LSTM) and gated recurrent unit (GRU) are used instead. For example, LSTM RNN-based diagnosis was demonstrated in the work [3] and showed effectiveness in identifying fault categories, detecting the evolution of fault information and predicting the remaining life of the system.

In conclusion, deep learning-based methods of fault diagnosis in rotating machinery show better performance than traditional signal-based approaches, enabling precise detection, classification, and prediction of faults. These approaches reduce the need of manual feature extraction thus simplifying the process of fault diagnosis on early stages. The usage of CNNs allows to improve feature extraction step and gives additional flexibility for processing multidimensional data. RNNs, on the other hand, can analyze patterns in sequences of vibration signals.

REFERENCES

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