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Multi-fault diagnosis study on roller bearing based on multi-kernel support vector machine with chaotic particle swarm optimization

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Abstract: A novel intelligent fault diagnosis model based on multi-kernel support vector machine (MSVM) with chaotic particle swarm optimization (CPSO) for roller bearing fault diagnosis is proposed. Multi-kernel support vector machine is a powerful new tool for roller bearing fault diagnosis with small sampling, nonlinearity and high dimension. Chaotic particle swarm optimization is developed in this study to determine the optimal parameters for MSVM with high accuracy and great generalization ability. Moreover, the feature vectors for fault diagnosis are obtained from vibration signal that preprocessed by time-domain, frequency-domain and empirical mode decomposition (EMD) and the typical manifold learning method LTSA is used to select salient features. The experimental results indicate that this proposed approach is an effective method for roller bearing fault diagnosis, which has more strong generalization ability and can achieve higher diagnostic accuracy than that of the single kernel SVM or the MSVM which parameters are randomly extracted. [1]

Keywords: Multi-kernel support vector machine; Chaotic search; Particle swarm optimization; Roller bearing; Fault diagnosis.

1. Introduction

In modern industry, fault diagnosis plays an important role in accident prevention, human safety, maintenance decision-making, and cost minimization. Roller bearing is a crucial component in mechanical transmission systems that find widespread industrial applications. Any defects occur to one of its component during its operation will lead to serious damage for the entire mechanical system. Therefore, it is essential to develop the reliable condition monitoring and fault diagnosis method to prevent the roller bearing from malfunction. Vibration analysis is the most commonly method for detecting roller bearing failures. Nowadays, based on vibration signal, various fault diagnosis and condition monitoring systems have been proposed in actual roller bearing detection [1]. These systems can provide the necessary sensor and data capture capability required for monitoring. Though some advanced signal processing methods, such as wavelet, Wigner-Ville, correlated transform and so on, have been applied in these systems, fault diagnosis yet needs the operators' decision in practical applications. This kind of diagnosis is not autonomous, nor is it always accurate because it is based on experts' experience. Artificial neural network (ANN) is the artificial intelligence method which is commonly used for machinery fault diagnosis. ANN uses historical data instead of human experience and has strong robustness of data analysis that can get better diagnostic accuracy than conventional method. However, the diagnostic accuracy of ANN cannot be high enough due to the limitations of 'over-fitting', slow convergence velocity and relapsing into local extremum easily [2].

Support vector machine (SVM) is a novel machine learning method first proposed by Vapnik in early1990s [3]. SVM can achieve automatic recognition for roller bearing complex faults. Based on statistical learning theory, SVM has strong robustness and great generalization abilities. This property is very important for roller bearing

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