Original Manuscript

Journal of Vibration and Control
2023, Vol. 0(0) 1–16

DOI: 10.1177/10775463231191684
journals.sagepub.com/home/jvc
Sage

Cross-domain diagnosis of roller bearing faults based on the envelope analysis adaptive features and artificial neural networks

Haider Suhail Najim and Jaafar K Alsalaet

Abstract

Traditional machine learning techniques depend on both the training data and the target data having the same data distribution and feature space. The performance may be unsatisfactory if there is a discrepancy in data distribution between the training data and the target data, which is known as a cross-domain learning issue. In this study, a technique for addressing this issue based on using the envelope analysis features coded as inputs to the Artificial Neural Networks (ANN) is presented. Specifically, three major cross-domain difficulties were resolved, including defect identification of different roller bearing types, rotating speeds, and loading conditions. The envelope approach is used to extract more distinguishing features at fundamental fault frequencies from the original signal, with the benefit of derived features being independent of both roller bearing type and operating conditions of rotating machines. The diagnosis outcomes were achieved experimentally through three different types of rollers bearing. Meanwhile, for each bearing type, three data sets were obtained at three different rotational speeds with different levels of fault categories to simulate all the cross-domain tasks. Moreover, the ANN model was trained using data of a particular bearing type and a certain operating state, whereas data of other bearing types were utilized to test the cross-domain performance of the proposed technique. At the same loading condition, the results indicate a 99.5% average success rate for bearing Koyo 1205, a 98.33% average accuracy for bearing NU 205, and a 97.3% average accuracy for the defective bearing kit. Furthermore, the results indicate that the suggested technique can deliver accurate cross-domain detection. Also, the experimental results proved that the suggested technology is a potential strategy for industrial applications.

Keywords

cross-domain diagnosis, neural networks, envelope analysis, adaptive features, roller bearing

1. Introduction

Rolling element bearings are critical components of rotating equipment, and their failure can lead to catastrophic consequences and costly downtime. Bearing defect identification and diagnosis have received significant research attention (Alsalaet et al., 2016). In the field of rotating machinery maintenance, there is a high demand for bearing condition monitoring and defect diagnostics. However, the presence of multiple vibration components in rotating equipment makes it challenging to identify fault situations, especially in the early stages (Abdulrazzaq, 2019). Machine learning approaches have been successfully applied to roller bearing fault detection. However, traditional machine learning techniques rely on training and testing vibration data from the same domain, assuming identical data distribution and feature space (Chao et al., 2022; Huo et al., 2017; Zhu, 2021). When training data belongs to one domain and testing data comes from a different domain, the diagnosis accuracy of these models significantly decreases. Furthermore, collecting training data that matches the data distribution and feature space of testing data in real rotating machine applications is challenging (Zheng et al., 2019).

In roller bearing fault diagnosis, training a fault classification model using data recorded and labeled under specific load, bearing type, and motor speed is insufficient

Mechanical Engineering Department, College of Engineering, University of Basrah, Basrah, Iraq

Received: 27 February 2023; accepted: 12 July 2023

Corresponding author:
Haider Suhail Najim, Mechanical Engineering Department, College of Engineering, University of Basrah, aljahiza, basrah-Al Zubair 61006, Iraq.
Email: pgs2404@uobasrah.edu.iq