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Detection of Rolling-Element Bearing Faults with Different Conditions

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***Abstract* - Bearing fault diagnosis is essential for the maintenance, durability, and reliability of rotating machines. It can minimize economic losses by removing unplanned downtime in the industry due to the failure of rotary machines. In bearing fault detection, developing intelligent techniques that can diagnose faults under different operating conditions is still a critical issue. In the current work, an intelligent fault diagnosis technique scheme is proposed for the detection of fault patterns for a given faulty bearing. A hybrid feature pool is employed in combination with artificial neural networks ANNs to perform highly effective diagnoses at various motor speeds. The hybrid feature pool is carefully extracted from both time and frequency domains. Envelope analysis is used to extract more discriminating frequency features from the raw vibration signals, while time-domain features are obtained from raw and filtered signals. With the use of 400 test samples with five bearing conditions for each rotating speed in the experiment, an accuracy rate between (97.25%) to (99.75%) was achieved based on time-frequency domain features while yielding an accuracy of (100%) based on frequency features for all rotating speeds. From the conducted tests, it can be concluded that the suggested method can accurately diagnose faults even when the network is trained at a certain speed and used to diagnose at other operating speeds.**

Keywords—rolling elements bearings, artificial neural networks, time domain, frequency domain, envelope analysis.

I.INTRODUCTION

Rolling element bearings are essential components in every rotating machinery, failure of roller bearings may lead to catastrophic breakdown and expensive downtime. Therefore, bearing defect detection attracts a lot of attention and has been the topic of extensive studies [1]. Bearing condition monitoring and defects diagnosis are highly demanded in modern machinery maintenance techniques. Due to the multiple vibration sources in rotating machinery, the vibration signals are surrounded by noise and random patterns; as a result, it is difficult to capture the fault conditions, especially in the early stage of the defect [2]. However, there are two diagnosis models: the traditional physical model and data driven model. With the complication of modern industries, the first approach loses its effectiveness and becomes inaccurate, especially with high complexity and a noisy system like that of intelligent manufacturing. Recently, intelligent data driven approaches have been developed with high accuracy [3]. In addition, data driven type is able to process vibration signals of rolling bearing effectively and provide successful fault diagnosis without requiring prior knowledge. Also, very promising faults classification in modern industries and a large number of studies were implemented using intelligent techniques, such as (ANN) [4], random forest (RF) [5], principal component analysis [6], and other improved methods [7].

Toumi Yassine et al. [8] used the envelope analysis and ANN technique to classify the bearing faults. Three types of bearing cases are presented: normal condition, inner race fault, and outer race fault. The learning and testing processes were achieved at 25 HZ shaft rate. The result shows the effeteness of ANN in rolling element bearing faults classification.

Zhiqiang Chen et al. [9] employed three different neural network models (Stacked Auto-Encoders, Boltzmann Machines, and Deep Belief Networks) to identify the bearing condition in seven fault patterns and healthy conditions. In addition, the features collected from time, frequency, and time-frequency domains are used to evaluate the performance of the neural network models. The results proved that the three models are highly reliable and applicable in fault diagnosis of rolling bearing.

Didik Djoko Susilo et al. [10] employed the support vector machine SVM as an identification technique for roller bearing faults. Meanwhile, five features were selected for normal condition, inner race, and outer race faults. The SVM showed excellent classification results for different roller-bearing conditions. The ANNs have good capabilities and excellent faults detection in cases where the training and diagnosis are at the same shaft speed. The effectiveness and accuracy of ANN in rolling element bearings classification may become unreliable when the operating speed is different from the one used at training. Hence, it is essential to develop a more general ANN classifier independent of shaft speeds and gives high diagnosis accuracy. This work has two major goals: First, to design a more general ANN faults classification approach that is not affected by shaft speeds variation and can be applied to fault diagnosis for a wide speed range. The second goal is to detect faults at the early stages of growth. The remainder of this paper is organized as follows: The methodology of the suggested faults bearing classification approach and the main process are introduced in Section II. Fault diagnosis experiments for rolling bearing are presented in Section III. The actual experimental evaluation and results analysis of the