Chapter 3
Deep Learning-Based Industrial Fault Diagnosis Using Induction Motor Bearing Signals

Saiful Islam
Ahsanullah University of Science and Technology, Bangladesh

Sovon Chakraborty
European University of Bangladesh, Bangladesh

Jannatun Naeem Muna
United International University, Bangladesh

Moumita Kabir
European University of Bangladesh, Bangladesh

Zurana Mehrin Ruhi
Brac University, Bangladesh

Jia Uddin
Woosong University, South Korea

ABSTRACT

Earlier detection of faults in industrial types of machinery can reduce the cost of production. Observing these machines for humans is always a difficult task, for that purpose we need an automated process that can constantly monitor these machines. Without continuous monitoring, a huge downfall can happen that can cost enormous monitory value. In this research, we propose some transfer learning models along with LSTM for earlier detection of faults from vibration signals. Open source Case Western Reserve University (CWRU) dataset has been used to detect four types of signals using transfer learning models. The four classes are Normal, Inner, Ball, Outer. The dataset has divided into three parts namely set1, set2, and set3. VGG19, DenseNet-121, ResNet-50, InceptionV3, and LSTM are applied to that dataset for detecting faults in this signal. The earlier result shows VGG19, LSTM and InceptionV3 can predict the faults in signal with 100% accuracy in the validation set where DenseNet-121, Resnet-50 show an accuracy of 97% and 98% respectively.

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INTRODUCTION

With the advent of the 4th industrial revolution, industry experts along with scientists all over the world have put on a considerable amount of effort to minimize all kinds of errors associated with a specific industry process & maximize efficiency. Keeping this objective in mind our research work illustrates the possible methods & strategies to detect industrial faults. In electromechanical engineering, motion is usually identified by mechanical device structures, which leads to satisfactory records of almost 70% of the gross energy ingestion in the field of modern manufacturing economics (Khan & Kim, 2016; Saidur, 2010).

Statistics have shown that a significant portion of industrial damage accounted for delayed diagnosis or identification of errors in the last one or two decades. The main motive of our research is to implement an effective indicator that can differentiate faulty signals & accurate signals of an induction motor.

Our research primarily focused on induction motors due to their extensive practical applications in the industry. The record has shown that almost 70% of the equipment & machinery in the commercial sector uses a three-phase induction motor. From residential to commercial & industry level, an induction motor is considered to be the most widely used type of machine. The simple yet robust construction, affordability with minimal maintenance & high-reliability characteristics always provide the induction motor a competitive edge in the industry as well as in residence. Induction motors have widespread applications in pumps, wind turbines & generators, where they are accountable for more or less than 70% of the gross energy consumption (Khan & Kim, 2016; Saidur, 2010). From household appliances like pumps, compressors, small fans, mixers, drilling machines to heavy machinery including lifts, cranes, oil extracting mills, textiles are just a few of the major applications where induction motor use case is exponential & most preferable. Various signature analyses of vibrations & motor currents have also been considered in the field of research to guarantee improved reliability (Soualhi et al., 2013). Railway components are quite essential for passenger safety purposes. There are lots of faults on this rail line. As a result of failures, the train and rail track components may be blemished (Karakose & Gencoglu, 2013; Santur et al., 2016; Yaman et al., 2017a). Rail flaws have been published by the International Railway Association (UIC) with UIC 712 R code (UIC-712 R, 2002).

Every machine has its characteristics and is prone to show abnormalities in various cases due to numerous problems. It is imperative to assess these unusual behaviors of the machines & incorporate corrective measures to restore the faulty machines within the shortest possible amount of time. Due to so many fault cases not limited to the stator side and rotor side, there are some techniques developed by the scientists along with other industry specialists. Fault Diagnosis & Detection (FDD) is one of the techniques that is being used for a long time. It is the process of uncovering faults or errors in the system while attempting to identify the source of the problem.

However, Conventional Fault Diagnosis & Detection (FDD) techniques have only been used to check the pattern of the process to point out any anomaly throughout the pattern. This technique allows the engineers to monitor whether the system is behaving as per the standard operating procedure defined in general. Signal processing is always an essential part of the three sectors. These signal processing techniques can be classified into the time domain, frequency domain & time-frequency domain (Yuan et al., 2012). Unfortunately, this traditional technique might not be able to expose several hidden attributes and the faults associated with those attributes, which make it difficult for the industries to not only address but also to meet the demand of the business through operational excellence.