Condition based monitoring for fault detection in windmill gear box using artificial neural network

N Abishekraj¹, G R Jeeva Prashanna¹, M S Suriyaa¹, T Barathraj¹, D Mohanraj²
¹Undergraduates, Department of Production Engineering, PSG College of Technology, Coimbatore, India
²Assistant professor, Department of Production Engineering, PSG College of Technology, Coimbatore, India

E-mail: abishekraj6464@gmail.com

Abstract. Gears are condemning element in a diverse industrial application such as machine tool and gearboxes. Many contributing losses occur due to an unexpected breakdown of the gears. Recently, in many researches fault diagnosis has been the most contributing content in the gears. Vibration analysis has been used as a deciding tool for several machinery maintenance decisions. The most efficient form of indication is by the increment in the vibration level. By measuring and analysing the machine’s vibration, it is possible to determine both the nature and severity of the defect, and hence predict the machine’s failure. The vibration signal of a gearbox carries the signature of the fault in the gears and early fault detection of the gearbox is possible by analysing the vibration signal using different signal processing techniques. The present work depicts about the predictive maintenance program implementation based on the experimental data set of the gear box assembly in wind turbines by using the Artificial neural network and comprises of the prediction of variation in the accuracy of the experimental data set. The code values are generated using python 3.7 version software. The accuracy of the Model was found to be 61.86%. This accuracy indicates the functioning of the gears and can also be used for predictions in real time scenario.

1. Introduction

Wind Turbines are one of the efficient and most contributing factors for power production in diverse countries and thus it is essential to reduce the costs for the operation involved and particularly maintenance. Condition based monitoring is a mechanism widely used to predetermine the failures in order to reduce the downtime and also to increase productivity. The advancements in the conditioned monitoring of wind turbines, explains several maintenance implementations are used [1].

The turbine data suggests that for huge turbines becomes fatigue more regularly and therefore essential for high prolongation of it. Minimizing the coast involved in maintenance and also frequent inspection would hence provide significantly higher as the space constraint of the wind turbine and numbers were constantly increasing day by day [2].

Condition monitoring of machine in industry has an influential tag due to the necessity of maximizing reliability and minimizing the appropriate losses of production breakdowns of machines [3]. One noted factor was that the bearing misalignment leads to the failure of the machine. Therefore, fault detection of bearing and diagnosis has significant effect on the preventive maintenance program [4].
Though a consumed group of attributes that picturises several combinations of defects which could be more complex, diverse attributes are essential for the efficient sets of detective defects and thus, preventively cost effective is required for computational place progress. In order to maximize the precision of the distinguishing factors and to accelerate the computation, a specific character should be developed accordingly [5].

The predictive maintenance using the analysis of vibration is the best possible mechanism employed to monitor machine operating condition and early detection of fault diagnosis in order to minimize the downtime and cost involved in the maintenance of the gears [6].

The vibration analysis includes measurement of vibrations and its elucidation. Initially, the vibration signals are obtained using the vibration analyser in frequency and time domain perspective with the built in Fast Fourier Transform analyser and the details collected from the indications of vibrations, which could be predicted using machine fatigue, increase the consumption of possible assets and to maximize the machine life. The measurements of vibration are taken in a cyclic manner such as once in a week or half a month and the vibration was continuously controlled and monitored by comparing the past measurements with the existing data. When the machine is new, the vibrations are seemed to be having small variation. Thereby, as the time goes on the faults enumerate and the dynamic processes in the machine change which in turn modifies the vibration spectrum [7].

Artificial neural networks are creating attention in recent days. It was applied fortunately to several fields of engineering such as biological modelling, decision and restrain and ocean investigation mainly because of its novel allocated statistical representation and simultaneous architecture [8]. The BP neural network have better abilities of associative memory, self-adaptation, self-study, self-organization, parallel distributed processing and parallely its good nonuniformity in shape identification technology was an adaptable and efficient mechanism to work out very intricate state of new identified distractions in the gearbox defect verification [9].

The present work depicts about the predictive maintenance program implementation based on the experimental data set of the gear box assembly in wind turbines by using the Artificial neural network and comprises of the prediction of variation in the accuracy of the experimental data set

2. Method
Artificial Neural Networks are the most fundamental element of Deep Learning. They are adaptable, robust and scalable, which develops optimal challenges in a huge manner and highly intricate machine
learning activities which are able to categorize several million of images, endorsing the good videos to watch out of the frequent users of hundreds of millions every day and empowering speech recognition services. MLP comprises of two or more layers called hidden layers and the last layer of LTUs called the output layer. Each layer leaving out the output layer consists of a bias neuron and was completely interlinked to the next layer.

An ANN having more hidden layers which is complex to solve are known as deep neural network (DNN). In general, for every training stage the backpropagation algorithm initially makes the prediction, identifies and measures the error, then scans through each and every layer in reverse mode to note the contribution of error from each connection and henceforth slightly modifies the connection weights to decrease the error. This process was explained in the figure 1 as shown [10].

In this method, the sample training data set was downloaded from the internet. The data set contains the vibration frequency in KHz from 4 different sensors which was placed at the ends of the gearbox. The output parameters were based upon whether the data collected were healthy and broken vibration data. This helps in determining the actual condition of the gearbox. The neural network was trained using back propagation technique and with the downloaded dataset. In order to get optimal accuracy rate, the dataset was downloaded from openai website. The data from all sensors was nearly 2,00,000 from each of the sensor and was plotted all together using matplotlib library in python. The pictorial representation of the data-set of all 4 sensors are as shown in figure 2.

The above shown graph represents the data obtained by all the 4 sensors from the windmill. The Various sensor were represented by different colouring. From this graph, it was clear that the sensor 1 (denoted by red colour) shows a clear variation for the defected gear box and healthy gear box.

The figure 3 represents the pictorial representation of data from sensor 1. There was a clear difference between healthy gearbox and broken gear box. The data obtained between ±20 Khz were found to be healthy and this was found in most of the data analyzed.

The graph containing the pictorial representation of the remaining three sensors in figures 4, 5 and 6 shows no significant difference between broken and healthy gear box. Almost all the data obtained between ±20 Khz were found to be healthy. This states the exact condition of the windmill gearbox.

The code was written in python with SciKit learn, pandas, numpy Libraries. SK learn has an open source library exclusively used for implanting machine learning algorithms. The data was downloaded in the form of text file, so the data was first converted from .txt file to .csv file. Then the csv was imported into environment using pandas data frame. The Label encoder built-in function was used to label the state of the vibration (i.e. Healthy/Defective).
Figure 3. Pictorial representation of sensor 1.

Figure 4. Pictorial representation of sensor 2.

Figure 5. Pictorial representation of sensor 3.
Windmill Gearbox Fault Diagnosis data having the vibration dataset was measured by utilising Spectra Quest’s Gearbox Fault Diagnostics Simulator. The data which was noted with the use of four vibration sensors which is situated in each corners of diverse directions. Since the data contains value from 4 different sensors, the hidden layer limit was set at 3 and maximum iteration is set at 1000. Further increasing in hidden layers and iterations will require some additional GPU support.

To find the accuracy of our Multi-Layer Perceptron model, the data was split into test data and train data. The training data of both X and Y columns was used to train the model. The test data was used to predict results. The SK learn library will compare predicted result to actual result to find the accuracy of model. The training data contains 80% of the total data.

3. Results and discussion
The accuracy of the Model was found to be 62% of the data were found to be healthy and the rest of the data was found to be defective. This was found using the SK learn library. This also proves that the model could run until 50% of the data was found to be defective. Moreover, this helps in the predictive maintenance of windmill gearbox using the ANN model satisfactorily.

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