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FAULT DIAGNOSIS OF AUTOMOBILE GEARBOX USING ARTIFICIAL NEURAL NETWORK

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ABSTRACT: Gears are very critical and essential device in power transmission systems, industries etc.. to vary speed and load conditions according to the requirements. It has a wide area of application in the field of rotating machinery. In recent years, the operational accuracy of gears are increasing as demand increases. Some minor errors like gear misalignment, backlash and tooth cracks after running for some period of time, will create some form of vibration which will affect the supporting components like bearings, shafts etc.. to fail. So it is very important to monitor the condition of gears to avoid the run time breakdown of machines. Vibration measurements are used to monitor the condition of the machine for predictive maintenance and to predict the gearbox faults successfully.

In this work propose the use vibration signal for automated fault diagnosis of gearbox and the statistical features that extracted from the vibrational signal are given as an input to the Deep learning algorithm ANN (Artificial neural networks) for fault identification. We can collect the vibrational datas from vibrational sensors that placed on gears. By using vibrational data and the load in the vehicle we can predict the fault in the gear box accurately.

KEYWORDS: Deep Learning, Artificial Neural Network, Automobile Gearbox,

INTRODUCTION: Gears are very critical and a controlling component in power transmission systems, it is having wide area of application in the field of rotating machinery. In recent years the operational accuracy of gears are increasing as demand increases. Some of the minor errors like gear misalignment, backlash, and tooth cracks after running for some period of time this defect will create some form of vibration which will affect the supporting components like bearings, shafts etc.. to fail. So it is very important to monitor the condition of the gears to avoid run time breakdown of the machine. The time-domain diagnostic algorithm is developed for monitoring the gear faults which has improvement in the extraction capability.

Vibration is the behavior of machine's mechanical component as they react to internal or external forces. Vibration signal analysis is mainly employed as it is an effective approach in detecting and diagnosis of faults in gears in a power transmission system. Continuous monitoring of gearbox vibration signals detects the deterioration due to propagation of faults which tells the defect in gear, in order to schedule the proper shutdown to avoid unexpected shutdown cost and time. Excess load, manufacturing error and installation error affects the dynamic behaviour of gears in transmissions. The fault in gear creates periodic impulses which in turn transmitted to adjacent parts. So the vibration signal should be detected early to avoid failure of whole system. The future of condition based maintenance research would be a design of intelligent device, which continuously monitor its own health using online data acquisition, online signal processing and online diagnostic tools. Compared to other monitoring techniques vibration signals are better and it is a very popular technique to reduce cost and enable diagnosis.

LITERATURE REVIEW:

[1] The paper "A time domain approach to diagnose gearbox fault based on measured vibration signals" by Hong and Dhupia (2014) proposes a new time-domain method for detecting and identifying gear faults in gearboxes. The method combines the fast dynamic time warping (Fast DTW) and correlated kurtosis (CK) techniques to extract the periodic impulse excitations caused by the faulty gear tooth and identify the corresponding faulty gear and its position. Fast DTW is a technique for aligning two time-series signals that may have different lengths and speeds. It is used in this paper to align the measured vibration signal with a reference signal that has the same frequency as the nominal gear mesh harmonic. This allows the periodic impulse excitations caused by the faulty gear tooth to be extracted from the measured vibration signal. The extracted signal is then resampled and analyzed using the CK technique. CK is a measure of the non-Gaussianity of a signal. In the context of gear fault detection, it can be used to identify the presence of periodic impulse excitations in the signal. The position of the faulty gear can then be estimated by finding the peak of the CK curve. The authors evaluated the performance of their method on simulated and

experimental vibration signals. The results showed that the method was able to detect and identify gear faults with high accuracy. The method was also shown to be robust to noise and variations in operating speed. The main contribution of this paper is the development of a new time-domain method for detecting and identifying gear faults. The method is based on the combination of Fast DTW and CK techniques, which allows it to extract the periodic impulse excitations caused by the faulty gear tooth and identify the corresponding faulty gear and its position. The method was shown to be effective in detecting and identifying gear faults in simulated and experimental vibration signals.

[2] The paper proposes a statistical model of gear vibration signals that can be used to detect and diagnose gear faults. The model is based on the assumption that the gear vibration signal can be decomposed into a set of sinusoidal components with different frequencies and amplitudes. The parameters of the sinusoidal components are estimated using the least-squares method. The authors evaluated the performance of their model on simulated and experimental vibration signals. The results showed that the model was able to detect and diagnose gear faults with high accuracy. The model was also shown to be robust to noise and variations in operating speed. The main contribution of this paper is the development of a statistical model of gear vibration signals that can be used for fault detection and diagnosis. The model is based on a simple and intuitive assumption, and it is relatively easy to implement. The model was shown to be effective in detecting and diagnosing gear faults in simulated and experimental vibration signals.

[3] The paper investigates the performance of two statistical fault detection indicators, the root mean square (RMS) and kurtosis, for three different series of crack propagation scenarios in a spur gear. The crack propagation scenarios are:

- Crack propagating through the whole tooth width with a uniform crack depth distribution.
- Crack propagating through the whole tooth width with a parabolic crack depth distribution.
- Crack propagating in both the depth and the length directions simultaneously.

The authors used a dynamic simulation model to generate vibration signals for each crack propagation scenario. The vibration signals were then analyzed using the RMS and kurtosis indicators. The results showed that the RMS indicator was more sensitive to the first crack propagation scenario, while the kurtosis indicator was more sensitive to the second and third crack propagation scenarios. The authors concluded that the choice of fault detection indicator should be based on the specific crack propagation scenario. The main contribution of this paper is the investigation of the performance of different statistical fault detection indicators for different crack propagation scenarios. The results of this study can be used to improve the accuracy of gear fault diagnosis.

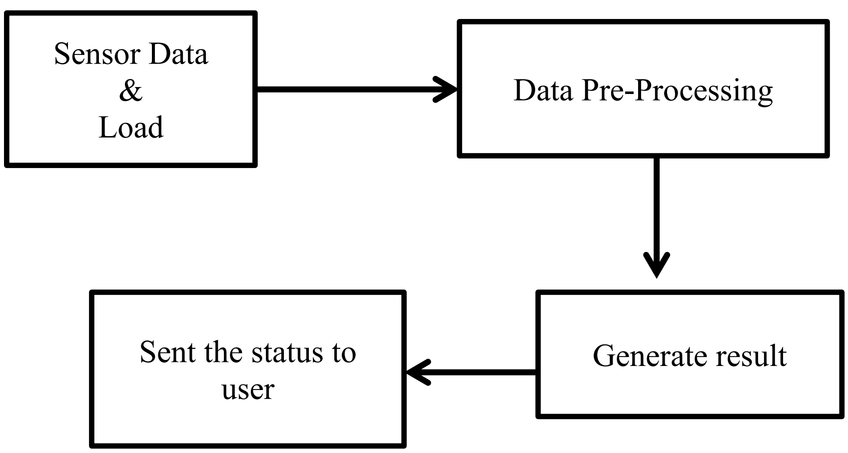
[4] The paper proposes an analytical model to quantify the reduction in gear mesh stiffness caused by a tooth crack. The model is based on the potential energy method, which considers the elastic deformation of the gear teeth and the contact forces between the teeth. The crack is modeled as a line defect in the tooth, and the model is used to calculate the change in the gear mesh stiffness as a function of the crack length and location. The authors validated the model against finite element simulations. The results showed that the model was able to accurately predict the reduction in gear mesh stiffness caused by a tooth crack. The model was also shown to be insensitive to the choice of material model. The main contribution of this paper is the development of an analytical model to quantify the reduction in gear mesh stiffness caused by a tooth crack. The model is simple and easy to use, and it can be used to quickly assess the impact of tooth cracks on gear performance.

[5] The paper proposes a novel method for detecting faults in moving machines using sound. The method uses a microphone to record the sound emitted by the machine, and then analyzes the sound signal to identify the presence of any abnormal frequencies or patterns. The authors evaluated the performance of their method on a simulated gear fault. The results showed that the method was able to detect the fault with high accuracy, even when the machine was moving at high speed. The method was also shown to be robust to noise and variations in operating conditions. The main contribution of this paper is the development of a novel method for detecting faults in moving machines using sound. The method is non-contact and can be used to detect faults in a wide range of machines. The method is also relatively inexpensive and easy to implement.

The main disadvantages of these papers are in the accuracy. They all have the accuracy around 75-85%. So, in order to improve the accuracy we propose another model that aims to detect the faults in the gearboxes using vibrational sensors. In this system we place 4 vibrational sensors on the gearbox to collect the vibrational data. The vibrational sensor consists of piezoelectric crystal that has a seismic mass attached to it. When the machine/equipment under study experiences vibrations, the crystal is subjected to stress and an electric signal is generated, which is then converted to valuable data. The collected vibrational data is preprocessed and then features are extracted from the data. After that training the data, then evaluate the final result ie, the gearbox is faulty or healthy. Vibration signal analysis is an effective approach in detecting and diagnosis of fault in gears. Here we use Artificial Neural Network for the identification of fault in gearbox. This system has some advantages: -

- The prediction accuracy is achieved around 90.58%.
- The data training time is less.
- The time-domain diagnostic algorithm is developed for monitoring the gear faults which has improvement in the extraction capability.

BLOCK DIAGRAM OF PROPOSED SYSTEM:



SYSTEM OVERVIEW:

Data gathering is the 1^{st} step and this process is followed by Data pre-processing. The statistical feature extraction from vibration data, required features are extracted for fault detection from 4 vibration sensors and load. Statistical features were extracted from the acquired data and it is passed to the ANN for feature classification. Gearbox diagnosis using trained ANN and evaluates the status of gearbox.

- Data Gathering
- Data pre-processing
- Fault diagnosis detection
- Feature extraction
- Training
- Evaluation

a) Data Gathering

The dataset used is Open Energy Data Initiative(OEDI). It consists data of both healthy and fault diagnosis. This dataset contains csv files. These files are aggregated into single one and most relevant features are extracted from it.

b) Data Pre-Processing

Each csv file in the dataset contains raw data. This data should be preprocessed before feeding it to the algorithm. For this, first we aggregate all those csv files and parsing is also done. The file created in this way is treated as the master file. From this master file, features are extracted. This data contains integers and strings. So, it is to be encoded before giving it to the algorithm. The missing values should be filled with mean value of the feature.

c) Fault Diagnosis Detection

We find the fault from the attributes done by that data.

d) Feature Extraction

Csv files are parsed and relevant data fields are extracted. We predict the fault diagnosis of gearbox with which are dealing. All relevant features are encoded. The encoded values are given to the algorithm to make prediction presence of a feature is represented by '1' while absence by '0'.

e) Training and Evaluation

The model is trained. The difference between input and output is calculated. This input is reconstructed to the output in the training phase. The model is trained during testing phase, when we give a new data of a fault diagnosis, the reconstruction error will be high. A threshold value is set to segregate healthy and faulty diagnosis. If value is higher than the threshold, it is predicted as fault data, otherwise as healthy data.

CONCLUSION:

Fault diagnosis of automobile gearbox based on deep learning techniques is one of the important studies in the field of condition monitoring of rotating machinery. Classification efficiency of healthy and faulty gear with two different speeds and load conditions was carried out and the classification efficiency of four gears was quoted. ANN shows better classification ability in identification of a various faults in the gearbox and it can be used for automated fault diagnosis.

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