The vibration monitoring system on the belt using neural network and interface with Labview and android apps

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Abstract. Detection of belt conditions as a connector on the AC motor can be done by knowing how characteristics vibration signals. All vibration signals are processed by using Fast Fourier Transform (FFT) to the frequency domain. The vibration signal spectrums are collected and processed by the Neural Network method so that conditions of the belt can be grouped. The cause of the actual condition can be monitored on Labview and Android apps. The proposed method is based on analyzing frequency-domain features with the Neural Network. On this paper, it uses two hidden layers on the Neural Network. The Result of the experiment based on three grouped of the condition can get accurate by 94.03% to 96.52%.

1. Introduction
Using the belts on 3 phase motors is very likely to happen. This is related to the flexibility of use suitable with the layout on the existing machine or system. Continuous use of the belt and different loading on operation can make be broken, so the belt replacement will be processed.

Belt replacement on a 3 phase AC motor takes a long time. This repair for belt starts from ordering tool, replacement, and validation. Ordering equipment usually requires time depending on the type of belt used with existing stock in the market, and make repairing time become uncertain. This uncertain process, if it occurs in factory production, will cause a loss. For this reason, the action is needed to detect early damage to the belt in the 3 phase AC motor.

Belt condition anomalies can be detected from vibrational changes that occur [1-3]. However, supporting parameters are needed to get accurate conditions, such as the temperature of the device, current and input voltage. The results of the vibration data are nonlinear values, so we need a method for data pressing and grouping.

Based on previous research by identifying the signal vibration of the belt, it can be seen the difference in signal vibrations results [4], this is the basis for development by adding a Neural Network (NN) algorithm. In the development of a monitoring system that is carried out on an electric motor [5], this is the basis for a vibration monitoring system on an electric motor using Labview and connecting with an Android smartphone. Thus the real-time conditions recognizing belt data can be known and preventive maintenance measures can be done.
2. Vibration monitoring design

2.1. Vibration system design
The design of the vibration monitoring system using a vibration transducer. Some transducers can find out the parameter values of vibration signals such as displacement, velocity, and acceleration [2]. However, transducers who observe displacement conditions will be difficult because of the installation process and the determination of reference points. Unlike that, the velocity or acceleration transducer installation is simple and does not require a reference point.

The detected signal is a combination of vibrations caused by the belt and the AC motor. To facilitate observation before the NN, additional methods are needed namely Fourier Transform [6,7]. This is a Fourier Transform formula.

\[ X_n = \frac{1}{N} \sum_{r=0}^{N-1} x_r e^{-i\omega r t} \]

The results of vibration data for machine system conditions have non-linear values. One of the influencing factors is temperature [8-10]. Vibration values obtained from two mediums with the same input force values but have different temperatures will produce different vibrations. So with one of the different parameters will have two results/data groups that indicate the same condition. For this reason, an appropriate nonlinear data processing method is needed. One of them is NN. NN is a learning algorithm that is built by perceptron (input) and neurons (functions) [10,11]. Each perceptron will be multiplied by a weight matrix, then from these results entered into functions such as logsig, tansig, etc.

2.2. Hardware design

Hardware design can be seen in figure 1. Vibration generated by the motor and the connected belt will be captured by the transducer placed at points 8 and 10. While the temperature transducer is placed at point 7. All transducers are connected to the Atmega324P for the ADC process. Analog data is read by the ADC on the microcontroller will be forwarded again to the PC through serial communication. On the PC there is a Labview software program to process the received serial data.
2.3. Principle of working system
The process of reading the input parameters is carried out by each transducer consisting of the velocity of vibration, temperature, electric current and voltage. Especially for voltage parameters, manually inputted into the Labview, while the other parameters are read through the ADC Atmega324P. In the Labview used, there is additional software, namely Linx as a reading of serial communication between a PC and a microprocessor. The results of the Linx reading will be forwarded to the Matlab program. Matlab program can be called via Labview, so signal processing with Fourier Transform and NN can be utilized by using the toolbox. There are two NN processing modes:

- **Train a Neural Network model.** The data that has been stored during the process will be used to determine the weight and bias matrix. It is important to know that each data taken needs to be determined for target or condition.
- **Apply a Neural Network model.** Weight matrix results and bias matrix that has been obtained will be used with ongoing input data.

For the reading process by a smartphone it needs to be added:

- Json is a connection tool between Labview and firebase.
- Firebase is for the process of storing data which can then be used by smartphones
- App Inventor 2 is to build an Android application. The results of the data stored in Firebase will be read by an android application that has been created by App Inventor 2
- Sublime text 3 is an online data storage process that can then be used for data transmission.

The following is a flowchart program that can be seen in Figure 2 and block diagram of the belt condition detection system process which can be seen in Figure 3.

![Flowchart software program and the NN process](image-url)

**Figure 2.** Flowchart software program and the NN process.
3. Experimental method

The drive motor will be coupled with a motor that is not turned on, then connected using a belt. The belt will be stretched in such a way as to analogize the condition of the belt as a new condition (A), will be damaged (B), and already damaged (C). The design of the distance of each group can be seen in Figure 4 with the following details.

- Condition A: 80 cm from the drive motor.
- Condition B: 90 cm from the drive motor.
- Condition C: 100 cm from the drive motor.

4. Results and discussion

Determine the condition of the test data results (apply mode) after a NN for each condition is used Euclidean distance for calculating error. The results from the euclidean process will determine the current conditions related to the group that has been determined. The Euclidean distance formula between points p and q used is [12]:

\[ ||q - p|| = \sqrt{(q - p) \cdot (q - p)} \]  

(2)
The vibration signal that has been processed can be seen in Figure 6 with the same temperature, electric current and voltage value. It can be seen that the resulting vibration signal has a different magnitude and frequency. This is caused by the change in belt length. For Condition A, the parameters can be seen at frequencies ± 0 Hz and ± 200 Hz. Whereas for Condition B there are frequencies ± 125 Hz, ± 110 Hz, and ± 55 Hz. Likewise, with condition C, although it almost resembles condition A, there can still be differences in the value of magnitude and frequency.

After the training process and applying it, the results can be seen in Figure 7. The interface in Labview displays several indicators of the results of measurements made using sensors. In addition, it can also process data stored in the database and sending data to smartphones.
Indicators of vibration test results in categories A, B and C can be seen in Table 1. The average error value from ten data can be obtained from each condition varies from 3.48% to 5.97%. High errors were found in condition C. This is because of the training data retrieval factor whose value is somewhat far from the data for testing when using the NN method.

| Condition | Target Average of Error |
|-----------|-------------------------|
| A         | 3.48%                   |
| B         | 3.40%                   |
| C         | 5.97%                   |

5. Conclusion

Vibration monitoring application that has been made can help in knowing the condition of the belt in real-time with an approach using Fourier transform and the NN which is directly applied to the program in Labview. The results of vibrations from each condition with the same parameters can be seen as the difference. That is what is the basis for grouping that is carried out by NNS. The input data used to vary the frequency characteristics of each condition. So that the NN input data process will be more optimal. The accuracy obtained is 94.03% to 96.52%. In the future, additional methods are needed for the process of simplifying data but still represent the real situation, so that the computational process during neural net learning becomes optimal.

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