

Vibration State Classification and Identification of the Quayside Crane Motor Based on Genetic Algorithm

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Abstract: After a period of operation, the quayside crane motor will change. It is necessary to classify and identify the vibration state of the quayside crane motor. This paper presents an application of the genetic algorithm in vibration state classification and identification of the quayside crane motor. This article shows an engineering example and classifies and identifies the vibration state of the quayside crane motor in the last day successfully. This paper provides some suggestions on the use and maintenance of the quayside crane based on the vibration state of the quayside crane motor.

1. Introduction

Because of the rapid development of container transportation, the utilization rate of the quayside crane is higher and higher in port logistics transportation. Whether the normal operation of the quayside crane can be guaranteed will directly affect the working efficiency and economic benefit of the port. [1, 2] As a result, more and more crane motor operating state of the quayside crane is detected and evaluated.

Under normal running condition, the vibration of the motor output shaft is regular and the vibration intensity is smaller because of the symmetry of the structure. But with the motor running, the material fatigues and even the internal components damages of motor. For example, the inner and outer rings of the bearing appear to be punctured and rotor section or rotor eccentricity of motor will make the vibration law of motor output shaft become more complex and increase the vibration intensity. The working environment of quayside crane motor is complex, and the vibration law of motor output shaft is also more complicated, but the vibration intensity of motor output shaft has obvious linear relationship with motor damage [3]. By classifying the vibration intensity of the lifting motor, the classification and recognition of the vibration state of the lifting motor on the quayside crane can be realized [4].

Genetic algorithm (GA) is an adaptive global optimization search algorithm for simulating natural selection and genetic mechanism in biological world. It uses simple coding and reproduction mechanisms to solve very complex problems. It was first proposed by Professor Holland of Michigan University in the United States. The algorithm is robust, stochastic and global. In this paper, search five distribution centers of vibration intensity data of output shaft of crane motor for a period of time based on genetic algorithm and count the number of data at each central point [5]. The vibration intensity distribution of the output shaft of the crane motor is obtained during this period because of the fixed interval of each data acquisition time [6]. Some suggestions can be provided on the use and maintenance of the quayside crane based on the distribution because of the distribution can reflect the damage of crane motor [7].



2. Detection method of vibration state of the quayside crane motor

First of all, we collect data through sensors on the shore bridge. Then using genetic algorithm to find the classification center of crane vibration state from the data. Finally, based on the vibration classification center of the quayside crane motor, the collected vibration data are classified and counted.

2.1 Data collection

System of monitoring and assessment for crane based on intranet(Net-CMAS) can automatically obtain the mechanical condition detection data of the shore bridge, which brings advanced detection and monitoring technology for the maintenance and management of port equipment. The experimental data in this paper are derived from the vibration signal on the shaft of the crane in Net-CMAS. Because Net-CMAS collects data every 10 seconds, it can collect about 8,000 data a day. The raw data are shown in figure 1.

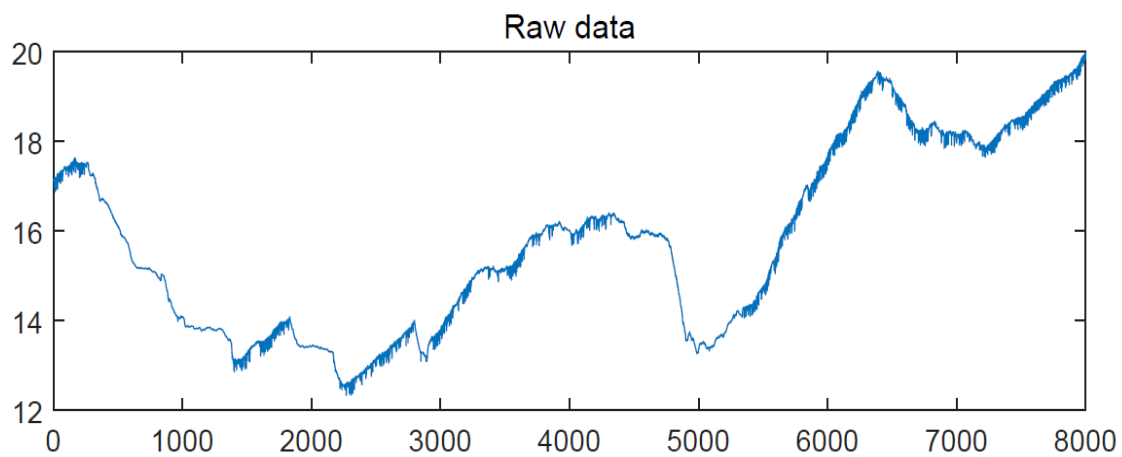


Figure 1. The raw data

2.2 Genetic algorithm

The calculation of fitness is very important in genetic algorithm. Fitness is the criterion for determining whether an individual needs to be retained. The adaptability in this article should include the following factors:

- 1) The Euclidean distance (d_{ik}) of the cluster center i and the other point k .
- 2) Comparison of Euclidean distance of other points k and cluster center i with cluster center j .
- 3) The fitness of different individuals should have a certain degree of differentiation, which is convenient for screening.

Therefore, the objective function equation is first established:

$$J = \sum_{k=1}^n \sum_{i=1}^c u_{ik} d_{ik}^2 \quad \dots \quad (1)$$

In the form, u_{ik} is the matching function. It plays the role of comparing the rest of point k with cluster center i and its Euclidean distance with cluster center j ; d_{ik}^2 is the square of the Euclidean distance between the cluster center i and the other points k .

$$d_{ik}^2 = (x_i - m_k)^2 \quad (2)$$

$$u_{ik} = \frac{1}{\sum_{j=1}^c (d_{ik} / d_{jk})^{10}} \quad (3)$$

The larger the fitness degree, the smaller the objective function value should be, so the fitness function should be established:

$$f = \frac{J'}{J} \quad (4)$$

In the form, J is the minimum value of the objective function; J' is the target function value.

The probability of crossover should be as follows:

$$P_c = \begin{cases} \frac{k_1}{2} \left(1 - \sin \left(\frac{\pi}{1 - \bar{f}} \left(f' - \frac{1 + \bar{f}}{2} \right) \right) \right) & f' \geq \bar{f} \\ k_1 & f' < \bar{f} \end{cases} \quad (5)$$

In the form, f is the fitness of the individual; $f_{\max}$ is the highest fitness in the population; $\bar{f}$ is the average fitness in the population; k_1 is the blending coefficient.

The probability of mutation should be as follows:

$$P_m = \begin{cases} \frac{k_2}{2} \left(1 - \sin \left(\frac{\pi}{1 - \bar{f}} \left(f - \frac{1 + \bar{f}}{2} \right) \right) \right) & f \geq \bar{f} \\ k_2 & f < \bar{f} \end{cases} \quad (6)$$

In the form, f is the fitness of the individual; $f_{\max}$ is the highest fitness in the population; $\bar{f}$ is the average fitness in the population; k_2 is the blending coefficient.

$$\begin{cases} N = \left\lceil \frac{n}{500} \right\rceil \\ k_1 = e^{-\frac{N}{20}} \\ k_2 = e^{-\frac{N^2}{10}} \end{cases} \quad (7)$$

In the form, n refers to the total number of individuals generating the initial population; The algorithm for the operator " $\lceil \cdot \rceil$ " is defined as " $\lceil a \rceil$ denotes the minimum integer greater than a ".

In this paper, the vibration state of the quayside crane motor is divided into five categories (They are named A B C D and E.), and the classification center increases in turn.

Based on the above adaptive genetic algorithm (GA), the MATLAB is used to find the five classifying centers of the vibration state of the crane motor in the data. Finally obtain the crane motor vibration status classification center (figure 2).

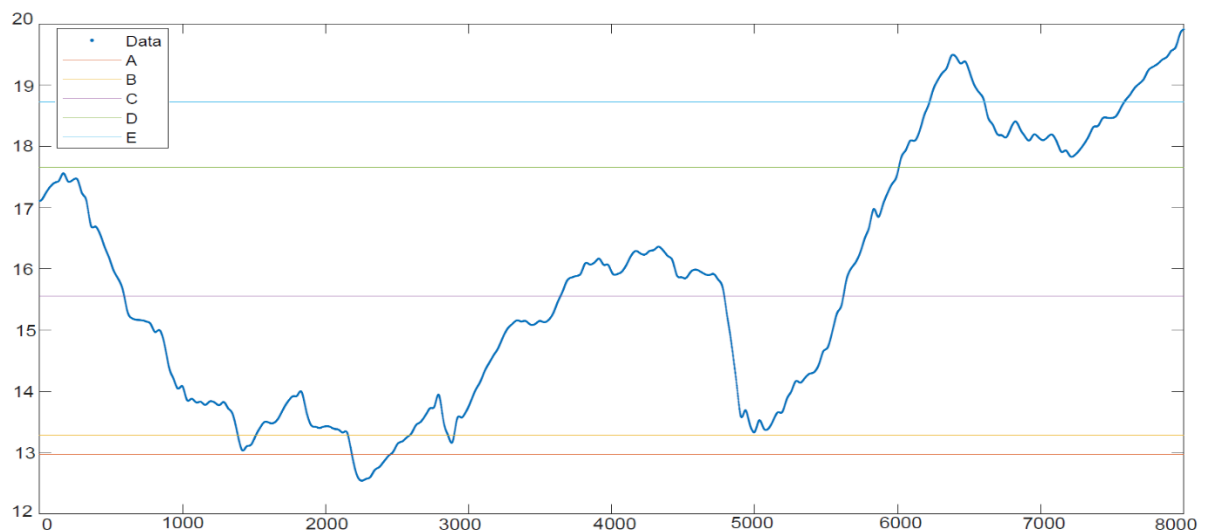


Figure 2. Classification center for vibration state of the quayside crane motor

Because Net-CMAS collects a data every 10 seconds, the proportion of the number of data in each class is equivalent to the proportion of time the motor works in this vibration state. Count the number of data in each crane vibration classification center and calculate the proportion of the data. The specific statistical results are shown in figure 3.

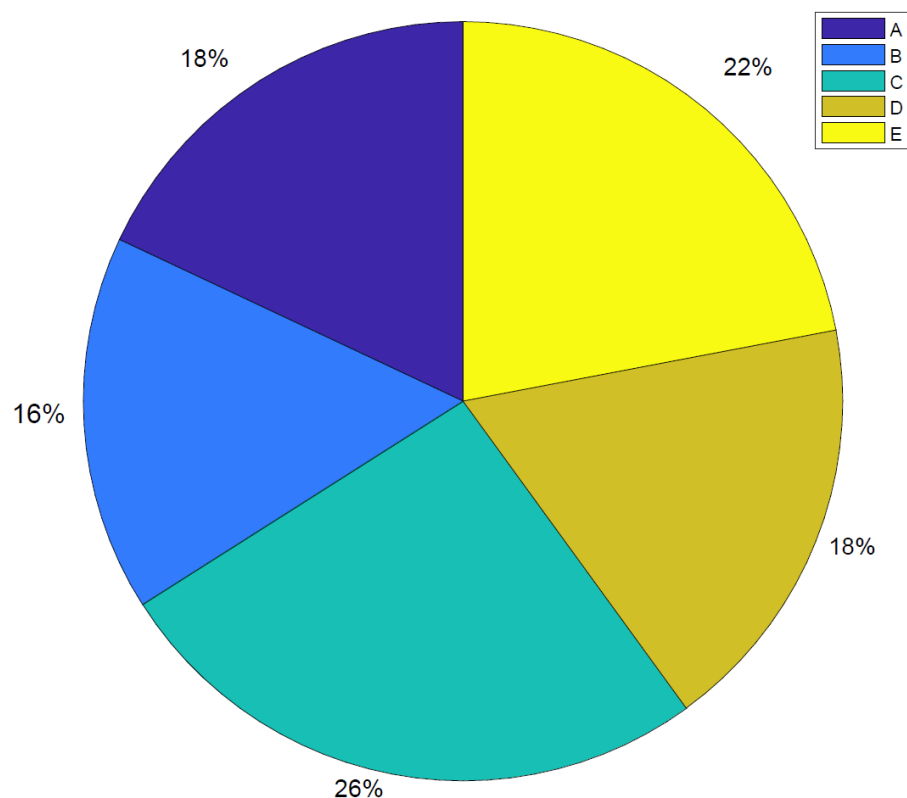


Figure 3. Classification results of vibration state of the quayside crane motor

3. Conclusion

In this paper, the classification center of vibration state of the quayside crane motor is successfully identified by genetic algorithm, and the working time distribution of the classification center of the

vibration state of the quayside crane motor is obtained. For example in this article, the vibration state of the quayside crane motor is 26%B and 22%A, and the distribution centers of A and C are 13.49276 and 16.14292, respectively. Therefore, the degree of motor wear is not large and the quayside crane motor can be used normally as long as it needs normal maintenance.

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