Artificial Intelligence Technology to Mechanical Vibration Wireless Sensor Monitoring Terminal Design Research

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Abstract. Mechanical vibrations have been noticed since they were discovered a long time ago. Because almost all machinery in the process of motion will produce vibration, some is due to the external force caused by vibration, and some external forces act on a substance to produce vibration caused by the resonance phenomenon, these will have an impact on the efficiency of the original machinery or internal performance. To solve these problems, scientists have been trying for many years to determine exactly why vibrations occur to achieve their goals by using vibrations or reducing them. Therefore, artificial intelligence technology is used to design and study the monitoring terminal of mechanical vibration wireless sensor. After querying the relevant data at home and abroad and carrying out a simple simulation experiment, this paper designs it by using a variety of algorithms, and finally selects a better algorithm to carry out the final fitting design and experiment. Finally, we chose the electronic tag image matching algorithm for system design. The experimental results show that the electronic label image matching algorithm is more accurate and the imaging speed is faster than other algorithms.

Keywords: Artificial Intelligence, Mechanical Vibration, Wireless Sensors, Monitoring Terminals

1. Introduction
Since artificial intelligence technology was put forward in 1960s and 1970s, it has made great progress after half a century of development. Although we are still in the era of weak artificial intelligence, now artificial intelligence has been able to do many things instead of human beings, such as fine operation instead of human beings and so on [1]. So, the research of this paper is to use artificial intelligence technology for mechanical vibration wireless sensor monitoring terminal design and experimental detection [2].

Such as diesel engine, generator set and other mechanical equipment in operation will produce vibration phenomenon. We can judge the running state of the equipment in advance by monitoring the signal generated by mechanical vibration, so as to avoid industrial accidents [3]. Therefore, in order to ensure the normal operation of the equipment, we usually equip the mechanical equipment with intelligent monitoring system and early warning system, so as to better observe the running state of the machinery [4]. After consulting the literature, we found that someone proposed a real-time online
diagnosis method of mechanical vibration. It is mainly used to collect the vibration signal of the mechanical group in the process of operation, extract the characteristic value of the signal, so as to construct the database, and then judge the mechanical vibration state on this basis. However, there is a problem with this method, that is, it has a very large amount of data calculation, and the data calculation process is very complex and error prone [5, 6]. So, we looked up another kind of literature, we found that he used a double sparse dictionary model to sense and judge the vibration signal, and finally completed the mechanical vibration monitoring. But this method also has a fatal disadvantage, that is, its calculation convergence is poor, and finally cannot get a fitting line or curve, cannot complete our experimental goal [7, 8].

So finally, we decided to use the electronic tag image matching algorithm in artificial intelligence technology to carry out the experiment [9]. Because the electronic tag image matching algorithm mainly uses scanning to convert various electrical signals into digital signals and present them in the display screen, which can intuitively observe the vibration wavelength, amplitude, peak and wave width ratio, and then establish a database to save the data, and then get the mechanical operation status at this time by comparing the fitting data [10].

2. Electronic Label Image Matching Algorithm

2.1. SIFT Feature Point Generation

The Gaussian scale core can define the scale space of the image using the refracting operation of the original image and a variable-scale 2D Gauss function:

\[ L(x,y,\sigma) = G(x,y,k\sigma) \ast I(x,y) \]  

(1)

\( G(x, y, k, \sigma) \) is the scale variable Gauss function, and \( I(x, y) \) is the original image; \( k \) is the amount of scale variation. In order to ensure the stability of detected feature points, different Gaussian differential cores and image recesses are generally used to generate Gauss differential space:

\[ D(x,y,\sigma) = G(x,y,k\sigma) - G(x,y,\sigma) \ast I(x,y) = L(x,y,k\sigma) - L(x,y,\sigma) \]  

(2)

For detected feature points, calculate the neighborhood gradient histogram and determine its primary direction. It is important to note that some feature points not only have the main direction, but also have a secondary direction, which is not always important for the stability of subsequent matches.

2.2. PCA Fundamentals

PCA is a statistical analysis method that converts multiple variables into a few new comprehensive variables through linear transformation, and the variance formula is

\[ \max_w \frac{1}{m-1} \Sigma_{i=1}^{m} (w^T(x_i - \bar{x})^2) \]  

(3)

\( m \) is the number of data involved in the dimensional reduction; \( x_i \) is the specific vector expression of random data \( i \); \( \bar{x} \) is the average vector of all the data involved in the de-dimensionality.

Definition \( W \) is a matrix consisting of column vectors of all feature mapping vectors, which can better preserve the information in the data, and the matrix can obtain an optimized target function through linear transformation

\[ \min_w (W^TAW), \ s.t., W^T W = I \]  

(4)

In the method: \( \text{tr} \) is the trace of the matrix; \( A \) is the co-variance matrix. The \( A \) expression is as follows:

\[ A = \frac{1}{m-1} \Sigma_{i=1}^{m} (x_i - \bar{x})(x_i - \bar{x})^T \]  

(5)

3. Experiment
3.1. Selection of Experimental Sites
Because this experiment is complex, simple testing in the lab does not meet all our needs for the experiment. So, we first vacuumed the lab to avoid interference from vibrations so that we could do what we needed to do better to avoid unnecessary experimental errors. Then we compare the experimental analysis and comparison of the mechanical vibration wireless sensor monitoring terminal by using a variety of algorithmic systems, and finally the experimental results are compared and analyzed.

3.2. Extraction of Experimental Data
Although we try to vacuum the experimental conditions and avoid interference from other substances. But in the course of the experiment is still difficult to avoid, resulting in some errors. But these errors are manageable and have a small impact on the final results, so we can ignore them. Therefore, in the later experiments, our main detection is based on the three algorithms designed by the different mechanical vibration wireless sensor monitoring terminal system to treat the objects measured by the experimental measurement of the data, and then linear coupling of them, the data will not be excluded, leaving reliable data for experimental analysis. So, we selected the better 20 sets of experimental data, and analyzed and compared them, and finally came up with the data comparison produced by the experiment.

4. Evaluation Results
4.1. Experimental Results Comparison

| Table 1. Comparison of the advantages of systems produced by various algorithms |
|-----------------------------------------------|----------------|-----------------|-----------------|
| | Data entry rate Mbit/s | Data processing rate Mbit/s | Image Image Rate m/s | Image rendering rate m/s |
|----------------|----------------|-----------------|-----------------|
| Eura algorithm | 360 | 34 | 0.04 | 0.03 |
| Cosine association algorithm | 290 | 28 | 0.1 | 0.05 |
| Electronic label image matching algorithm | 1210 | 127 | 1.1 | 0.7 |

After analyzing the data of Table 1, we find that the electronic label image matching algorithm is particularly fast compared to the cosine association algorithm and the Eura algorithm, which is about 1210Mbit/s. And its data processing rate is much faster than theirs, about five times that of the Eura algorithm and the cosine association algorithm, at 127. Therefore, its image visible rate is naturally much faster, reaching 1 1Mbit/s. The cosine association algorithm is only 0.1m/s, while the Eura algorithm is only 0.04m/s. This shows that although the data processing rate of the Eura algorithm is fast, its image visible rate is very slow. And the image rendering rate of the electronic label image matching algorithm is about 0.7, which is about nine times that of the Eura algorithm (0.03m/s) and the cosine association algorithm (0.05m/s). It shows that the electronic label image matching algorithm not only has the fast data input and processing speed, but also the image imaging speed is fast and accurate, which can describe the graphics situation we need very well.
Figure 1. Data analysis speed of various algorithms

Figure 2. Various algorithms Image visible molding speed
Because the data processing speed and image processing speed of the electronic label image matching algorithm are better than the other two algorithms, we use the electronic tag image matching algorithm and other artificial intelligence technology to build a mechanical vibration wireless sensor monitoring terminal to compare and analyze with the other two. The final experimental results are shown in Figure 1, Figure 2, after the column chart comparison is more intuitive than the text description, indicating that the algorithm is different, the results of the experiment are also different.

4.2. Mechanical Vibration
Mechanical vibration refers to the regular re-movement of an object or mass in a balanced substance. The strength or weakness of vibration is indicated by the vibration light, the amount of vibration can be the displacement, speed or acceleration of the vibration body. If the amount of vibration is beyond the mechanical capacity, the mechanical equipment will produce a large load and noise, which will affect the performance of the work and the life of the equipment. For example, the rupture of the fan blades and the resonance of the beams of the house, both of which can lead to extremely serious accidents. Due to the complex internal structure of modern machinery, and vibration causes a variety of reasons, which can lead to mechanical damage due to vibration. But vibration isn't just bad, for example, we can use vibration to achieve what we need to accomplish, such as the vibration of an air compressor.

In order to know the vibration signal of mechanical vibration or the cause, we need to build a dynamic model of the object under study to analyze the effects on him by detecting all the objects around it that may produce vibration. First of all, we have to measure the inherent properties of the object under study, such as material structure, bearings, tolerance range, stiffness and frequency. Then through artificial vibration to observe the frequency of internal vibration and the resulting effects, at this time through a long period of time through a number of experiments slowly dynamic analysis to know. Finally, the motion equation is modeled according to the resulting experimental parameters, and then the conditions and utility of the vibration of the measuring substance are known.

There are many kinds of mechanical vibration, the simplest mechanical vibration is the simple harmonic vibration of the mass. Simple harmonic vibration is the movement of time with sine function, its vibration displacement equation, vibration acceleration equation and vibration velocity equation are very simple, but in the actual vibration analysis process, it is generally not possible to appear a separate simple harmonic vibration, because the actual mechanical structure is very complex. So, when we analyze their vibration problems, we first need to simplify them into a whole mechanical system that combines several mechanical models and analyze them individually to find out. Then our simplified mechanical system is also divided into single-degree-of-freedom system and multi-freedom system. A single free system is a simplified mechanical system with a single state of motion and a single independent coordinate. The multi-freedom system, that is, the mechanical system has multiple independent coordinates. In general, we simplify according to the actual situation. Other mechanical vibrations are generally divided into free vibrations (vibrations determined by the physical properties of the system itself), forced vibrations (vibrations caused by the continuous excitation of the mechanical system from the outside world) and self-exciting vibrations (vibrations produced by the vibration of the system by its own parts).

4.3. Wireless Sensor
Wireless sensor, generally powered by a separate power supply, constitutes a wireless sensor network node, through self-organizing way to form a network. The types of sensors can generally be divided into three types, namely vibration sensors, strain sensors and torque sensors. The main feature of the vibration sensor is that the maximum sample rate of each node can be set to 4kHz, and each channel is set up with an anti-ambiguous low-pass filter, which collects data can be transferred to the cloud for storage, can also be stored on-premises servers for storage, to ensure the validity of the data. Strain sensors are characterized by compatibility with various types of bridge sensors, such as strain,
temperature, etc. The torque sensor is characterized by a particularly long standby measurement time of up to 2 to 3 days, and does not need to replace the battery, improving the maintenance-free system.

And wireless sensors wake up in a variety of ways, but there are four main ways. The first is full wake-up mode, where the wireless sensor is operating at full capacity but consumes more energy. The second is the random wake-up mode, where the network nodes in the wireless sensor wake up at random. The third is the prediction mechanism to choose wake-up mode, at which point the network node in the wireless network sensor selects the wake-up wireless sensor through the needs of the task. The fourth mode is task cycle wake-up mode, where network nodes in wireless sensors are periodically awakened due to a well-designed cycle.

5. Conclusion
In summary, after using a variety of algorithms to study and design the mechanical vibration wireless sensor monitoring terminal system, we use experimental comparison to detect the advantages and disadvantages of each system, and analyze and compare their advantages. Finally, it is found that the performance of electronic label image matching algorithm is better than that of the other two algorithms. Because of its data processing speed and image ococyst forming speed are very fast. It allows us to analyze vibration signals generated by mechanical vibrations in real time and display them in the display. It can alert us quickly to facilitate our real-time detection of mechanical movement anomalies and solve them to maintain the degree of mechanical perfection and ensure economic efficiency. Therefore, the results of our experiment should be more accurate, I hope to help you.

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