Power Optimal Control Method of Network Big Data for Mechanical Vibration Wireless Sensor

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Abstract. With the gradual deepening of research on wireless sensor networks at home and abroad in recent years, some wireless sensor network application systems have emerged in the fields of academic research and engineering applications. Especially in the industrial field, wireless sensor network, as a new information perception technology, has attracted more and more attention due to its advantages of self-organization, flexible deployment, strong scalability, and on-chip processing capabilities. The purpose of this paper is to study the power optimization control method of wireless sensor of mechanical vibration by network big data. In view of the current problem of power control of mechanical vibration wireless sensor network nodes, first, under the premise of ensuring the accuracy of data collection, the key factors affecting the power control of mechanical vibration wireless sensor network nodes are analyzed, the wireless sensor power control model is designed, and the network big data is proposed. Impact on the power of wireless sensors; finally, based on the above research, the fuzzy power control algorithm and its simulation are specifically studied. First, a point-to-point transmission power control system model is designed, and the fuzzy logic controller module is designed in detail, including fuzzy Part of the membership function design, fuzzy rule determination and the use of defuzzification methods. Then use simulation tools to build a point-to-point simulation model and a simulated network simulation model. Finally, these two models are used to compare the performance of fuzzy power control algorithm and fixed power method. The experimental results show that the network survival time using fuzzy power control algorithm is twice that of the fixed power method. The fuzzy power control algorithm has great advantages in both effective communication distance and network survival time.

Keywords: Network Big Data, Mechanical Vibration, Wireless Sensor, Power Optimization

1. Introduction
There have been many research branches in the field of wireless sensors, including node positioning, topology control, routing protocols, etc. [1]. As one of the main strategies of wireless sensor network topology control, power control technology has a significant impact on the energy efficiency,
throughput, and real-time performance of wireless sensor networks [2-3]. Power control technology can reduce energy consumption in wireless communication and is an effective means to extend the life cycle of wireless sensor networks [4-5]. In addition, it has a significant impact on network topology control and connectivity, throughput, real-time message delivery and other system performance, and provides an effective way to improve network service quality [6-7].

Power control technology is the core supporting technology for the successful application of wireless sensor networks [8]. Sharma V invented a device for supplying power from environmental energy to a load. The device includes an energy harvesting device for collecting energy from environmental energy sources, wherein the rate of energy harvesting from environmental energy sources is lower than the rate required to directly power the load. This system can be used to power sensors and transmit sensor data, such as tire pressure [9]. Moraes Ren introduced the composition of the wireless sensor node power module, which converts the collected mechanical vibration energy into electrical power. The characteristics of the vibration energy harvester and the power requirements of wireless sensor nodes are given. Finally, the most effective power processing scheme is summarized, and future research directions are pointed out [10].

The main innovations of this paper are as follows: The requirements of mechanical vibration sensor network nodes and the deficiencies of existing nodes are analyzed, and the power control algorithm for mechanical vibration wireless sensors is designed, which provides software for the application of wireless sensor network technology in the field of mechanical vibration. Hardware platform; combined with node self-organizing network, reliable data transmission, fuzzy power control algorithm and fuzzy power control algorithm optimization, a set of mechanical vibration wireless sensor network power control system is designed to initially realize the power control of mechanical vibration.

2. Research on Power Optimization Control Method of Wireless Sensors of Mechanical Vibration by Network Big Data

2.1 Wireless Sensor Power Control

When the forwarding coefficient is \( m_i \), the data collected by the circle \( C_i \) is forwarded through the circle \( C_{i-m_i} \) until the sink node. The energy consumption rate \( V_i \) of the circle \( C_i \) is:

\[
V_i = aK + t_\alpha P_a + t_\beta P_\beta + P_{rb} K_{r,i} + P_t (m_i r) T(k + K_{r,i}), i \in [1, n]
\]  

The number of bytes received by the ring \( C_i \) is:

\[
K_{r,i} = k \sum_{k \in s_i} N_K.
\]

The transmitting power of the nodes in the circle \( C_i \) is:

\[
P_t (m_i r) \frac{p_{thresh} (4n)^2 l_t}{\alpha_1 \alpha_2 \lambda^2} (m_i r)^2 \leq p_{max}.
\]

Define the network life cycle (t) as the duration from when the network starts to work until the first circle becomes the energy hole area, then:

\[
T = \min\left\{\frac{1}{V_i}\right\}, i \in [1, n]
\]

The energy consumption rate of the ring far away from the sink node is relatively large, and the ring \( C_n \) exhausts energy prematurely and becomes an energy hole area.

There must be a forwarding vector to maximize the life cycle of the network, but because the forwarding vector not only affects the transmission power of the nodes in each ring, it is also related to the amount of forwarded data of each ring, so any conjecture about the forwarding vector must be tested. Whether it is optimal or not, the above problem can be attributed to the optimization problem with the forwarding vector as the variable. The use of intelligent optimization algorithms such as genetic algorithm, annealing algorithm, and immune clonal selection can obtain an approximate
optimal solution, which can alleviate the energy hole problem of the network and extend Network life cycle.

2.2 The Impact of Network Big Data on the Power of Wireless Sensors

After the continuous collection of the mechanical vibration wireless sensor network node is completed, the large amount of raw vibration data generated after the mechanical vibration signal is converted by the analog-to-digital converter is stored in the external large-capacity NandFlash storage device. After the gateway node sends a data return command, the collection node begins to fetch data from the external Flash storage device through the serial communication interface and cache it to the node processor RAM memory, but the node occupies a large amount of memory capacity due to tasks such as operating system, protocol stack, etc., resulting in little remaining RAM capacity, which is stored in the external storage device the original vibration data must be read in blocks. When the sampling length is certain, the data reading energy consumption and reading current, storage module operating voltage, single reading time, single reading length (that is, data block size) related, the working voltage of the storage module is fixed at 3.3V, and the read current and single read time will be affected by the single read length.

3. Experiment on the Power Optimization Control Method of Mechanical Vibration Wireless Sensor by Network Big Data

This article adopts DSP controller and drive circuit. The DSP controller model is TI's TMS320F28335, with a main frequency of 150MHz. The controller has an enhanced pulse width modulation module (ePWM), various communication modules (SCI, SPI, CAN bus), etc., which can fully meet the requirements of the system. Through the designed mechanical vibration wireless sensor node, an experimental platform is built to analyze and verify the theory. The parameters of each node are exactly the same. The operating frequency of the system is 20kHz. The inductance value of the node is 105.54µH, and the compensation capacitor is 0.6µF. In the following experiment, in order to maximize the power transmission, the initial phase difference between nodes is set to θi-j=±/2. This paper designs two types of simulation models to compare different performance indicators. The first type of simulation model is the point-to-point simulation model. In this type of simulation model, the distance between nodes is getting farther, and the simulation compares the effective communication distance. The second type of simulation model is the simulated network simulation model, and the simulation compares the effective communication distance between nodes. The second type of simulation model is the simulated network simulation model, and the simulation comparison is the network survival time.

4. Analysis of Network Big Data on Power Optimization Control Method of Mechanical Vibration Wireless Sensor

4.1 Mechanical Vibration Wireless Sensor Power Control

The simulation compares the fuzzy power control algorithm with the fixed power method on the performance index of effective communication distance. The results show that as the distance increases, packet errors will occur in both schemes, but when an error occurs in the fuzzy power control scheme, the effective communication distance between nodes is longer; second, if the initial transmission power is low, the effective communication distance between nodes using a fixed power scheme will be shorter, but the effective communication distance between nodes using a fuzzy power control scheme will not change. In summary, the fuzzy power control algorithm can bring longer and more stable effective communication distance. The reason why it has such a big advantage is that it allows the sending node to maintain a variable, but reasonable transmission power. This transmission power can dynamically change with the feedback of the receiving end, bringing a longer and more stable effect. Communication distance.

The simulation compares the fuzzy power control algorithm and the fixed power method on the performance index of network survival time, as shown in Table 1.
Table 1. Comparison of network lifetime performance

| Algorithm                  | 20  | 40  | 60  | 80  | 100 |
|----------------------------|-----|-----|-----|-----|-----|
| Fuzzy power control algo.  | 2.0 | 1.8 | 1.5 | 1.2 | 0.9 |
| Fixed power method         | 1.0 | 0.9 | 0.7 | 0.55| 0.4 |

Figure 1. Network lifetime performance comparison

The solid line represents the simulation result corresponding to the fuzzy power control algorithm, and the dashed line represents the simulation result corresponding to the fixed power method as shown in Figure 1. It can be seen that the network lifetime using fuzzy power control algorithm is twice the lifetime of the network using fixed power method. This is because, in order to meet certain parameters and ensure communication quality, the fixed power scheme has to use a larger transmission power, because it does not know how much transmission power is appropriate. However, in an environment where the wireless channel changes, the fuzzy power control scheme can adjust the transmit power to an appropriate value through several rounds of fuzzy calculation.

4.2 Fuzzy Logic Control for Power Optimization

The improved fuzzy logic controller model is similar to the unimproved model. It also contains a fuzzy part, a fuzzy set part, a fuzzy rule part, a fuzzy calculation part and a defuzzification part, but the difference is that its fuzzy set is a secondary structure. It is composed of rough fuzzy set and precise fuzzy set. In the early stage of fuzzy adjustment, the input QoS and the best QoS are far behind. The fuzzy logic controller uses rough fuzzy sets to adjust the transmitting power of the sender in large steps, so that the input QoS of the receiving end can get closer to the best QoS as soon as possible. In the later stage of fuzzy adjustment, the input QoS is close to the optimal. At this time, if the rough fuzzy set is used, the transmission power adjustment in large steps will cause overshooting, that is, the input QoS always swings up and down the optimal QoS, which cannot be stabilized. There is no way to talk about how to approach the best QoS. Therefore, in the later stage of fuzzy adjustment, the fuzzy logic controller should use a precise fuzzy set with high precision and small step size.
The basic idea of accurate fuzzy set is to compress the domain of input membership function and output membership function according to the gap between input QoS and optimal QoS, avoid meaningless overshoot, and make the control more precise and effective. When the input QoS value has entered the range of the language operator of the rough fuzzy set. The fuzzy logic controller should abandon the use of rough fuzzy sets and use precise fuzzy sets, which can improve the accuracy and avoid overshoot. The design of the precise fuzzy set in this paper is completely consistent with the design idea of the fuzzy fuzzy set, but the scope of the input domain and the output domain are compressed, so that the accuracy of the input and output of the system is improved. The precise fuzzy set input membership function still uses the optimal triangular and Gaussian joint input membership function, and the division ratio of each function is almost the same. The precise fuzzy set output membership function still uses the simple Gaussian single output membership function used in Figure 1. The division ratio of the domain of each function is still the same, but the scope of the domain is compressed from the original full domain to the scope of the original language operator.

Table 2 shows the simulation comparison of the fuzzy logic controller with optimized precision and the fuzzy logic controller without precision optimization. The simulation results show that the system model performance of the fuzzy logic controller with optimized accuracy is better on the index of network survival time.

**Table 2.** Comparison of network lifetime between precision optimized and non precision optimized system models

|                    | 20  | 40  | 60  | 80  | 100 |
|--------------------|-----|-----|-----|-----|-----|
| Fuzzy power control algorithm | 2.3 | 2.1 | 1.8 | 1.67| 1.5 |
| Optimized power control algorithm | 2.5 | 2.42| 2   | 1.75| 1.66|

**Figure 2.** Comparison of network lifetime between precision optimized and non precision optimized system models

The simulation results show that the precision-optimized fuzzy logic controller can adjust the transmit power to a range closer to the optimal value, thereby effectively avoiding overshoot as shown in Figure 2. In this way, the node can save a little energy every time it launches, and the accumulation of multiple launches can also save considerable energy and extend the survival time of the network.
5. Conclusions
This paper focuses on the problem that the existing sensor network is difficult to be competent for the power control of mechanical equipment. It is very important to design a dual-processor architecture wireless sensor network power control algorithm to achieve the pickup of the vibration signal of the mechanical equipment. Self-organizing network big data and simulation experiments are also very important to form a complete set of mechanical vibration wireless sensor network. First, the optimization scheme of the input membership function is given, and these schemes are briefly analyzed. Simulation is used to verify the effect of the optimization scheme and select the better scheme. Then, the two-level fuzzy set is used to optimize the accuracy of the fuzzy logic controller. And simulated it. In comparison with the unoptimized fuzzy logic controller, the precision-optimized fuzzy logic controller can bring longer network survival time, which is consistent with the results of theoretical analysis.

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