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Research Article

Monitoring Area Coverage Based on Control Multimedia Nodes Position in Mixed Underwater Mobile Wireless Sensor Networks

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Due to the high cost of mobile nodes and the low cost of fixed nodes, in some applications of wireless sensor networks, in order to reduce the use cost, the mixed mode is used for node deployment. The deployed nodes include both fixed and mobile nodes. After the nodes are deployed, the fixed nodes do not move, and the mobile nodes move reasonably according to the network coverage to improve the network coverage effect. Due to the differences in equipment structure and use cost between fixed nodes and mobile nodes, in order to complete the monitoring task under the condition of reducing the use cost of wireless sensor networks, the number and position of mobile nodes can be reasonably adjusted as needed to improve the effective coverage area of wireless sensor networks. In the process of adjusting the position of mobile nodes, the moving distance of mobile nodes is fully considered. Simulation results show that this algorithm can improve the coverage effect of mixed wireless sensor networks and reduce the moving distance of mobile nodes.

1. Introduction

In recent years, due to the development of microelectromechanical systems, the sensor has many advantages, such as low cost, small volume, flexible deployment, good self-organization, strong concealment, high fault tolerance, and excellent intelligence [1]. The application of wireless sensor networks does not need fixed facilities such as base stations, can be deployed quickly, and has better flexibility [2]. Through multifunctional detection, cooperative perception, and cooperative communication, it significantly improves the accuracy of data acquisition and the reliability of data transmission and has obvious advantages in computing, storage, and energy efficiency [3].

The deployment optimization of sensor nodes is one of the most basic research work in the construction of wireless sensor networks [4]. The characteristics of deployment strategy in sensing the correctness and integrity of data not only directly affect the adaptability, stability, and monitoring performance of wireless sensor networks [5] but also play an important role in improving network connectivity, communication quality and perception quality, reducing application cost and node energy consumption, and prolonging the network life cycle [6]. Thus, the ability and comprehensive service quality of wireless sensors to effectively obtain physical information from the objective environment are finally determined [7].

In order to complete large-scale environmental monitoring, a very large number of sensing nodes can be placed in the monitoring area in two ways: deterministic deployment and random deployment [8]. In the area with an ideal external environment and manual operation, the method of artificial placement is usually used to carry out accurate and deterministic deployment according to the pre-calculated position [9]. In the military battlefield, marine exploration, volcanic earthquake disaster site and other high-risk, complex dynamic, or unattended specific areas, it is very difficult to realize deterministic deployment [10]. It is usually deployed randomly according to the dense and sparse requirements by means of aircraft scattering [11]. This method is less limited by geographical position and relatively low cost. It is an important supplement to the existing monitoring means and is of great significance [12].

Because sensor nodes are limited by their own energy load, computing power, wireless communication range, and other conditions [13]. Whether the wireless sensor network is constructed by deterministic deployment or random deployment, there may be an imperceptible blind area in the monitoring area due to sensor energy depletion, hardware physical failure or external environment change, target movement, obstacle occlusion and malicious attack, or the target cannot be tracked in time and effectively, resulting in the problem of "coverage blind area" [14]. In addition, an improper network node deployment scheme or node failure will also affect the connectivity of the network and the integrity of data collection [15].

For the construction of a traditional network, the main consideration is to improve the quality of service and the utilization of network bandwidth [16]. Wireless sensor networks pay more attention to how to make more effective use of the limited energy resources of nodes and take prolonging the network life as the main design goal [17]. In addition, how to maximize network coverage, how to eliminate the communication and monitoring the blind area in the process of network deployment, how to solve the problem of coverage blind area, and how to dynamically move, schedule or add new sensor nodes in time should be solved, so as to optimize or redeploy the network structure [18]. Wireless sensor networks need to be dynamically adjusted to adapt to the changes in the monitoring environment and ensure the smooth completion of target monitoring and information collection through reconstruction [19]. How to design an efficient deployment optimization strategy so that the network can have reliable performance and a longer life cycle on the premise of ensuring good monitoring quality is the key issue for further research on deployment optimization technology of wireless sensor networks in the future [20].

For the mixed network randomly deployed in the complex environment of three-dimensional underwater space, the node perception model is proposed in this article, uses the data fusion model, integrates the dynamic node management, and ensures the maximization of the network area coverage. It can reduce the number of nodes, energy consumption, and communication redundancy, prolong the service life of the network, and comprehensively improve the overall performance indicators such as network robustness and stability. Due to the complex structure of mobile nodes, the network cost is high after being widely used. In order to reduce the use cost of wireless sensor networks, monitoring area coverage based on control multimedia nodes position (MAC-CMNP) is proposed in this article. Due to the differences in equipment structure and use cost between fixed nodes and mobile nodes, in order to complete the monitoring task under reducing the use cost of wireless sensor networks, the number and position of mobile nodes can be reasonably adjusted according to the needs to improve the effective coverage area in wireless sensor networks. In the process of adjusting the position of mobile nodes, fully consider the energy consumption of mobile nodes, avoid nodes with less energy moving too long, and prevent these nodes from failure due to energy depletion. Simulation results show that the algorithm can improve the coverage effect of mixed wireless sensor networks, reduce the mobile distance of mobile nodes, and is suitable for the mixed network environment with complex structures.

The main contributions of this article are as follows:

(1) Summarize and analyze the existing monitoring area coverage algorithms.

(2) The problems in the existing monitoring area coverage algorithms are pointed out.

(3) A modified and improved monitoring area coverage algorithm is proposed.

The article is organized as follows:

(1) Background knowledge is introduced in Section 1.

(2) Related work is described in Section 2.

(3) Monitoring area coverage based on control multimedia nodes position (MAC-CMNP) is proposed in Section 3.

(4) Simulation results are analyzed in Section 4.

(5) Conclusion and future work are summarized in Section 5

2. Related Work

Shih Kuei Ping [21] studied the target coverage problem of wireless heterogeneous sensor networks with multiple nodes and proposed two solutions: residual energy first scheme (REFS) and energy efficient first scheme (EEFS) to solve the target coverage problem. In REFS, each node makes decisions according to the residual energy of itself and its neighbor nodes, so that it can work normally and ensure that there is network coverage on each target. Different from REFS, nodes in EEFS make decisions according to their own and neighbor nodes' perception and residual energy to ensure that each target is covered by the network. The simulation results show that REFS and EEFS can effectively prolong the network service time, and EEFS is better than REFS in network service time.

In order to improve the coverage and energy computing ability of mixed wireless sensor networks, Li Ming et al. [22] proposed a coverage control algorithm. Different from the existing algorithms that only use the rotation or mobility of nodes to solve the problems of similar sensor nodes, this method combines the rotation and mobility of nodes to improve the coverage and reduce the energy consumption. The method is divided into two stages: rotation stage and moving stage. In the rotation stage, the working direction and angle of the mixed sensor node are adjusted, and in the mobility stage, the specific position of the sensor node is changed. In these two stages, the step-by-step method and the virtual force-guided adaptive differential evolution algorithm are adopted, respectively.

Gou Pingzhang et al. [23] established the coverage blind area model between heterogeneous wireless sensor network nodes and proposed a multifactor collaborative hole repair optimization algorithm (FCH-ROA). Coverage blind area restoration not only determines whether mixed wireless sensor networks can work normally and effectively, but also determines the coverage, performance, and lifetime of the network. During the operation of the network, wireless sensor nodes are prone to coverage blind areas due to random deployment or network failure. Therefore, coverage blind area repair is a very key and challenging problem in heterogeneous wireless sensor networks.

In most existing works, coverage and connectivity are the main research contents. The network coverage that nodes cannot communicate with each other is meaningless. Monitoring the regional coverage effect and the connectivity of nodes in the network is a research hotspot. While maintaining network connectivity, using a small number of wireless sensor nodes to maximize network coverage is a problem to be solved. In order to solve these problems, Elma Johny and Meenakshi [24] determined the minimum active set through artificial bee colony optimization technology to provide Q coverage, and then the optimal connectivity management technology for accessibility to provide strong connectivity. In the existing solutions, the coverage effect of the monitoring area and the connectivity of nodes in the mixed wireless sensor network are not well improved. In order to solve these problems, network coverage scheduling and node power-aware connection technology are proposed. A dynamic clustering strategy is used to cluster mixed wireless sensor nodes. This method applies network coverage and node connectivity to the dynamic environment. While ensuring the connectivity of nodes in the network and reducing the number of mixed wireless sensor nodes, the optimal network coverage scheduling and node power-aware connection technology are proposed. In this technology, all nodes except the working node are put into sleep according to the energy consumption degree of the node, and the connectivity between nodes is guaranteed with the minimum power consumption. This method improves the network coverage effect and node connectivity of fixed nodes. It is mainly suitable for monitoring the occurrence of fire in the forest and the trend of the enemy in the battlefield.

For the problems of coverage blind area and coverage redundancy when randomly deploying sensor nodes in heterogeneous wireless sensor networks, Cao Li et al. [25] proposed an optimal coverage method for heterogeneous wireless sensor networks based on improved social spider optimization (SSO) algorithm, which reduces network energy consumption and improves network coverage. The mathematical model of heterogeneous wireless sensor network coverage is established, which is a complex combinatorial optimization problem. In order to improve the global convergence speed of the algorithm, the chaotic initialization method is used to generate the initial population. In the iterative optimization process, by simulating the movement law of the spider population, the optimal solution is finally obtained for the optimal deployment of sensing nodes in heterogeneous wireless sensor networks. On this basis, the optimization goal is to improve the network coverage, reduce the network cost, and effectively prevent the coverage blind spots and coverage redundancy in the network.

Coverage is a basic problem in wireless sensor networks. It plays an important role in network efficiency and performance. When sensor nodes are randomly dispersed in the network environment, a switch scheduling mechanism can be designed for these nodes to ensure network coverage and prolong network life. Rahmani Amir Masoud et al. [26] proposed an optimal area coverage method. The proposed area coverage scheme includes four stages: (1) calculate the overlap between the sensing ranges of sensor nodes in the network. At this stage, a new, distributed, and efficient method based on the digital matrix is proposed, so that each sensor node can estimate the overlap between its sensing range and other adjacent nodes. (2) A fuzzy scheduling mechanism is designed. At this stage, fuzzy logic is used to design the switch scheduling mechanism. In this fuzzy system, if the sensor node has a high energy level, is close to the base station, and the overlap between its sensing range and other adjacent nodes is low, the node will be turned on for a long time. (3) Predict node replacement time. At this stage, a suitable method is provided to estimate the death time of sensor nodes and prevent the coverage blind area in the network. (4) Rebuild and repair the coverage blind area in the network. The goal of this stage is to find the best position for mobile nodes to maximize coverage and minimize energy consumption for the repair of coverage blind areas. Therefore, the mixed frog leaping algorithm (SFLA) is used, and an appropriate multi-objective fitness function is proposed. In order to evaluate the performance of the scheme, NS2 software is used to simulate it, and the scheme is compared with CCA, PCLA, and CCM-RL. Simulation results show that this scheme is superior to other methods in the average number of wireless sensor nodes, coverage, energy consumption, and network lifetime.

Golrasan Elham et al. [27] studied the whole area coverage of wireless sensor networks and considered the coverage of deterministic and probabilistic mixed sensors. A new algorithm based on distributed game theory is proposed to maximize the coverage of the monitoring area and minimize the number of wireless sensor nodes. Due to the energy limitation in sensor networks, the trade-off between energy consumption and coverage quality needs to be considered when formulating the optimization function. The simulation results show that compared with the previous methods, the game theory algorithm has higher energy efficiency and maximum monitoring area coverage.

Wireless sensor networks are mostly used in outdoor and harsh environments. Therefore, the probability of node failure is very high, and the application of a fault-tolerant mechanism becomes very important. The arrangement of relay nodes is a mechanism to improve the connectivity of wireless sensor networks. Sheikhi Hemmat et al. [28] proposed a new method KCN. In mixed wireless sensor networks, k-connected wireless sensor networks are created based on relay nodes, in which sensor nodes have different transmission radii. KCN consists of three algorithms. Algorithm 1 creates a minimum k-vertex connected graph based on graph theory, algorithm 2 determines the candidate relay nodes and their positions to achieve each edge in the obtained graph, and algorithm 3 minimizes the number of deployed relay nodes based on two newly proposed formulas. The simulation results show that compared with the existing methods, KCN uses fewer relay nodes.

Karimi-Bidhendi Saeed et al. [29] studied a two-layer mixed wireless sensor network with access points (AP) and fusion centers (FC). The mixed node deployment problem is modeled as an optimization problem with the total network power consumption as the cost function. At the same time, the necessary conditions for the optimal deployment of AP and FC nodes are deeply discussed. Voronoi diagram is used as the best cell division method of the network, and it shows that each AP should be located between the FC connected to it and the geometric center of cell division. A mixed algorithm is also proposed to optimize the node deployment, and the sensor node deployment problem of sensor node and AP when the communication range is limited is studied. Simulation results show that the average performance of the algorithm is better than the existing clustering methods.

Eriskin Levent [30] considered the point coverage problem and located the mixed wireless sensor networks with uncertain targets. The uncertainty of target position is common in the military and security fields. Usually, the probability information about the target position can only be obtained through intelligence, historical data, and expert opinions. First, an integer nonlinear program is developed to locate mixed wireless sensor networks with central radiation topology in a given target scene. In this topology, wireless sensors form the lower network, and the hub forms the upper network by collecting data from sensors and fusing the transmitted detection data. Second, a linear approximation of the nonlinear model is proposed, which provides a calculation basis for solving large-scale problems. Then, a deterministic formula is designed, which considers multiple scenes at the same time and generates a compromise solution to ensure the coverage effect of a single scene. In the research of point coverage, the position problem of mixed wireless sensor networks is defined as the concept of target position uncertainty for the first time, and an effective robust optimization method is proposed. Finally, case research is given to illustrate the applicability of the proposed robust solution.

For the self-deployment of mixed directional wireless sensor networks in three-dimensional space, Tan Li [31] proposed a three-dimensional self-deployment algorithm based on a weighted Voronoi diagram (3DV-HDDA). In order to improve the network coverage of the monitoring area, 3DV-HDDA algorithm uses the weighted Voronoi diagram to move the sensor nodes, introduces the virtual boundary torque to rotate the sensor nodes to make the sensor nodes reach the best position, and also includes the improved algorithm based on the centralized sensor node position (3DV-HDDA-I). In 3DV-HDDA-I, the movement of nodes is determined by a weighted Voronoi diagram and virtual force. Simulation results show that the energy consumption of the proposed algorithm after 60 iterations is less than that of the virtual force algorithm, which proves the accuracy and effectiveness of 3DV-HDDA algorithm and 3DV-HDDA-I algorithm.

Wang Xinbing et al. [32] studied the coverage and energy consumption control of mobile heterogeneous wireless sensor networks and proposed equivalent sensing radius (ESR) in two cases. By adjusting ESR, the trade-off between coverage performance and energy consumption can be controlled. The relationship between network coverage and perceived range is proposed, which shows how network coverage changes with the change in perceived ability. The K coverage at a certain time and a certain period of time are studied, and it is concluded that the mobility of nodes can improve the network coverage effect.

With the increasing technical requirements of wireless sensor networks (WSNs), the optimal deployment of sensor nodes is considered to be one of the important factors that directly affect the network coverage. At present, the research to solve the coverage problem of mixed wireless sensor networks mostly has the disadvantages of high energy consumption and high cost. Al Fuhaidi Belal et al. [33] proposed an efficient deployment model based on a probabilistic sensing model (PSM) and harmony search algorithm (HSA) to achieve the balance between network coverage performance and network cost in the mixed wireless sensor network. HSA is used to optimize the deployment of mixed wireless sensor network nodes, so as to strike a balance between coverage and use cost. PSM is used to solve the problem of overlap between sensors. The performance of the model is analyzed from two aspects of coverage and cost evaluation. Compared with the Meta heuristic genetic algorithm in a mixed wireless sensor network, the simulation results confirm the effectiveness of the model.

Most existing fault detection schemes rely on the data perceived by adjacent nodes. However, these schemes usually do not consider the coverage problem. Masdari Mohammad and Suat [34] applied factors such as the difference of distance, coverage, and perceived value. By using the proposed distributed algorithm, each sensor node can correctly identify its state in the presence of events such as fire and transient fault. A large number of simulation results show that the algorithm is effective in reducing the false alarm problem in the process of fault detection and improving the detection accuracy.

One of the basic tasks of the development of wireless sensor networks is coverage. Most of the existing coverage studies focus on homogeneous and static wireless sensor networks, in which the sensor nodes have the same characteristics of perception, communication, and initial energy reserve. Ammari Habib [35] considered the differences of sensor nodes and the mobility of sink nodes, and the problem of K coverage and data collection in mixed wireless sensor networks is solved by using the Helly theorem. A multilayer architecture of mixed sensors and two data collection protocols are proposed. The optimal mobility strategy of sink nodes is studied to reduce the energy consumption in the process of data communication and sink node mobility. Simulation results show that the data collection protocol based on sink node mobility is better than the mixed data collection protocol based on geographic forwarding.

The above algorithms do not consider the problem that the mixed deployment of fixed nodes and mobile nodes can be used to reduce the cost. When a large number of fixed nodes are used, the deployment cost is low but the coverage effect is not good. When a large number of mobile nodes are used, the coverage effect is good but the deployment cost is high. Therefore, in order to solve this problem, monitoring area coverage based on control multimedia nodes position is proposed in this article.

3. Monitoring Area Coverage Based on Control Multimedia Nodes Position

Due to the differences in equipment structure and use cost between fixed nodes and mobile nodes, in order to complete the monitoring task under the condition of reducing the use cost of wireless sensor networks, the number and position of mobile nodes can be reasonably adjusted according to needs to improve the effective coverage area in wireless sensor networks. In the process of adjusting the position of mobile nodes, fully consider the energy consumption of mobile nodes, avoid nodes with less energy moving too long, and prevent these nodes from failure due to energy depletion. Simulation results show that the algorithm can improve the coverage effect of mixed wireless sensor networks, reduce the mobile distance of mobile nodes, and is suitable for the mixed network environment with complex structures.

3.1. Nodes Mathematical Model

$$P\left(p_i, s_j\right) = \begin{cases} 0 & \text{if} \quad d\left(p_i, s_j\right) \geq \left(R_S + R_e\right), \\ \dfrac{e^{\left(R_s+R_e\right)-d\left(p_i,s_j\right)/2R_e} - 1}{(e-1)} & \text{if} \quad R_s - R_e \langle d\left(p_i, s_j\right) \langle R_s + R_e, \\ 1 & \text{if} \quad d\left(p_i, s_j\right) \leq \left(R_s - R_e\right). \end{cases} \tag{1}$$

In formula (1), R_s is perception radius of the wireless sensor node, R_e is the perception error range of the wireless sensor node, and $d(p_i, s_j)$ is the distance between the pixel i and the wireless sensor node j [36].

3.2. Nodes Movement Model. The now coordinate of the node s_a is $(x_a^{now}, y_a^{now}, z_a^{now})$ in the monitoring area, the now coordinate of the node s_b is $(x_b^{now}, y_b^{now}, z_b^{now})$ in the monitoring area, and the distance between node s_a and node s_b is as follows:

$$d\left(s_a^{now}, s_b^{now}\right) = \sqrt{\left(x_a^{now} - x_b^{now}\right)^2 + \left(y_a^{now} - y_b^{now}\right)^2 + \left(z_a^{now} - z_b^{now}\right)^2}. \tag{2}$$

In formula (2), $d(s_a^{now}, s_b^{now})$ is the distance between node s_a and node s_b [37].

When $d(s_a^{now}, s_b^{now}) < 2R_s$, the distance between node s_a and node s_b is too close, the repulsive force is greater than the attractive force. When $d(s_a^{now}, s_b^{now}) > 2R_s$, the distance between node s_a and node s_b is too far, and the attractive force is greater than the repulsive force [38].

After calculation, the new coordinate obtained by the node s_a is $(x_a^{new}, y_a^{new}, z_a^{new})$, and the new coordinate obtained by the node s_b is $(x_b^{new}, y_b^{new}, z_b^{new})$.

When $d(s_a^{now}, s_b^{now}) < 2R_s$

$$x_a^{\text{new}} = x_a^{now} + \frac{\left(x_a^{now} - x_b^{now}\right)\left[2R_s - \mathrm{d}\left(s_a^{now}, s_b^{now}\right)\right]e^{\mathrm{d}\left(s_b^{now}\right)}}{\mathrm{d}\left(s_a^{now}, s_b^{now}\right)\left[e^{\mathrm{d}\left(s_a^{now}\right)} + e^{\mathrm{d}\left(s_b^{now}\right)}\right]C}, \tag{3}$$

$$y_a^{\text{new}} = y_a^{now} + \frac{\left(y_a^{now} - y_b^{now}\right)\left[2R_s - \mathrm{d}\left(s_a^{now}, s_b^{now}\right)\right]e^{d\left(s_b^{now}\right)}}{\mathrm{d}\left(s_a^{now}, s_b^{now}\right)\left[e^{d\left(s_a^{now}\right)} + e^{d\left(s_b^{now}\right)}\right]C}, \tag{4}$$

$$z_a^{\text{new}} = z_a^{now} + \frac{\left(z_a^{now} - z_b^{now}\right)\left[2R_s - \mathrm{d}\left(s_a^{now}, s_b^{now}\right)\right]e^{\mathrm{d}\left(s_b^{now}\right)}}{\mathrm{d}\left(s_a^{now}, s_b^{now}\right)\left[e^{\mathrm{d}\left(s_a^{now}\right)} + e^{\mathrm{d}\left(s_b^{now}\right)}\right]C}, \tag{5}$$

$$x_b^{new} = x_b^{now} + \frac{\left(x_b^{now} - x_a^{now}\right)\left[2R_s - \mathrm{d}\left(s_b^{now}, s_a^{now}\right)\right]e^{\mathrm{d}\left(s_a^{now}\right)}}{\mathrm{d}\left(s_b^{now}, s_a^{now}\right)\left[e^{\mathrm{d}\left(s_b^{now}\right)} + e^{\mathrm{d}\left(s_a^{now}\right)}\right]C}, \tag{6}$$

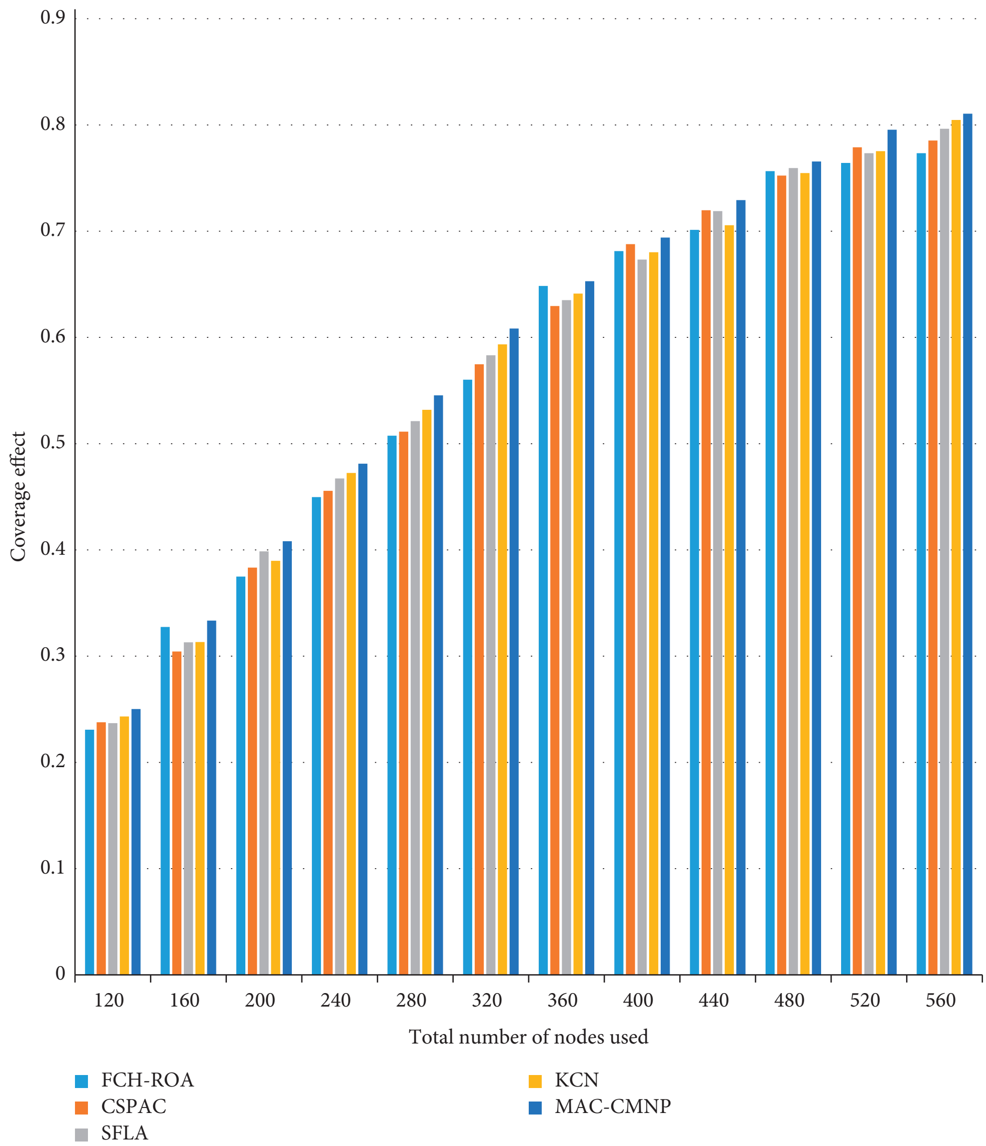

Figure 1: Coverage effect in different algorithms.

$$y_b^{new} = y_b^{now} + \frac{(y_b^{now} - y_a^{now})\left[2R_s - \mathrm{d}(s_b^{now}, s_a^{now})\right]e^{\mathrm{d}(s_a^{now})}}{\mathrm{d}(s_b^{now}, s_a^{now})\left[e^{\mathrm{d}(s_b^{now})} + e^{\mathrm{d}(s_a^{now})}\right]C},$$

$$z_b^{new} = z_b^{now} + \frac{(z_b^{now} - z_a^{now})\left[2R_s - \mathrm{d}(s_b^{now}, s_a^{now})\right]e^{\mathrm{d}(s_a^{now})}}{\mathrm{d}(s_b^{now}, s_a^{now})\left[e^{\mathrm{d}(s_b^{now})} + e^{\mathrm{d}(s_a^{now})}\right]C},\tag{7}$$

$$d(s_a^{new}) = d(s_a^{now}) + \sqrt{(x_a^{new} - x_a^{now})^2 + (y_a^{new} - y_a^{now})^2 + (z_a^{new} - z_a^{now})^2},\tag{8}$$

$$d(s_b^{new}) = d(s_b^{now}) + \sqrt{(x_b^{new} - x_b^{now})^2 + (y_b^{new} - y_b^{now})^2 + (z_b^{new} - z_b^{now})^2}.\tag{9}$$

In formulas (3) to (9), $d(s_a^{now})$ is the sum of the distance that the node s_a moved before this movement, $d(s_b^{now})$ is the sum of the distance that the node s_b moved before this movement, $d(s_a^{new})$ is the sum of the distance that the node s_a moved after this movement, $d(s_b^{new})$ is the sum of the distance that the node s_b moved after this movement, and C is the control parameter of node moving distance [39].

When $d(s_a^{now}, s_b^{now}) \geq 2R_s$,

$$x_a^{new} = x_a^{now},\tag{10}$$

$$y_a^{new} = y_a^{now},\tag{11}$$

$$z_a^{new} = z_a^{now},\tag{12}$$

$$x_b^{new} = x_b^{now}\tag{13}$$

$$y_b^{new} = y_b^{now},\tag{14}$$

$$z_b^{new} = z_b^{now},\tag{15}$$

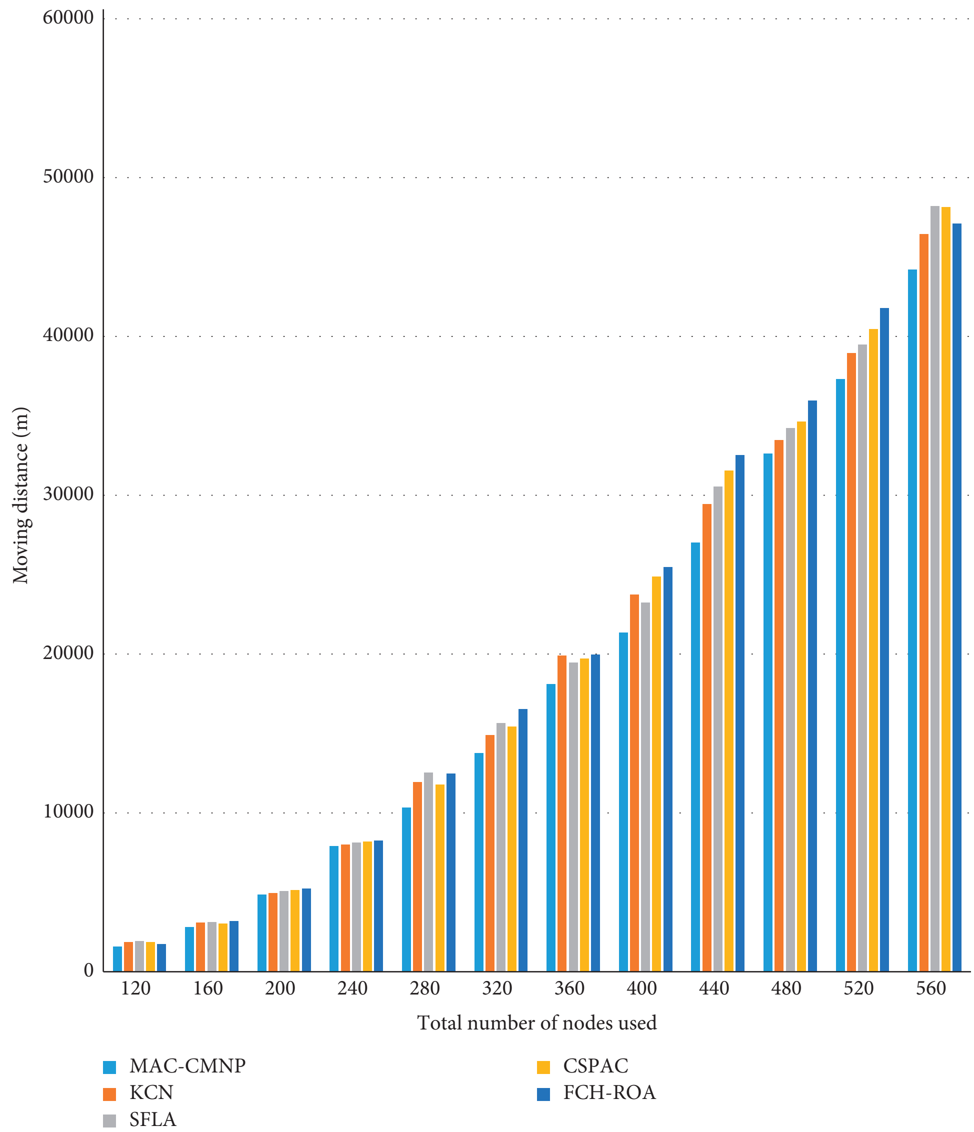

Figure 2: Moving distance in different algorithms.

$$d\left(s_a^{\text{new}}\right) = d\left(s_a^{now}\right), \quad (16)$$

$$d\left(s_b^{\text{new}}\right) = d\left(s_b^{now}\right). \quad (17)$$

3.3. Nodes Movement Process

Step 1. n wireless sensor nodes are randomly deployed in the monitoring area with length is L, width is W, and depth is D, including N1 fixed nodes and N2 mobile nodes. Each wireless sensor node has the same parameters.

Step 2. each wireless sensor node uses the positioning function to obtain its own position information and send its own position information to the sink node.

Step 3. the fixed nodes do not move. The mobile nodes use formulas (2) to (17) to calculate the movement direction and movement distance of the movable node.

Step 4. if the mobile node is outside the monitoring area after moving, the mobile node will not move.

Step 5. after the node movement is completed, if the preset number of cycles is not reached, the number of cycles $t = t + 1$, return to Step 2, and the algorithm process will cycle again.

Step 6. after the node movement is completed, if the preset number of cycles T is reached, the node movement process ends.

4. Simulation Result and Analysis

The length of the monitoring area is $L = 100$ m, the width of the monitoring area is $W = 100$ m, the depth of the monitoring area is $D = 100$ m, the node communication radius is $R_c = 20$ m, the node sensing radius is $R_s = 10$ m, the number of cycles is $T = 20$, and the control parameter of node moving distance is $C = 1$. The data set provided by reference [40] is used for simulation. In order to verify the effectiveness of this algorithm, under the same parameter conditions, MAC-CMNP algorithm is compared with FCH-ROA algorithm, CSPAC algorithm, SFLA algorithm, and KCN algorithm. Simulation is carried out when fixed nodes $N1 = 60$, 80, 100, 120, 140, 180, 200, 220, 240, 260, 280 and mobile nodes $N2 = 60$, 80, 100, 120, 140, 180, 200, 220, 240, 260, 280 are randomly deployed. The coverage effect after the node is moved and the moving distance after the node is moved is shown in Figures 1 and 2.

There are fixed nodes and mobile nodes in the monitoring area. Fixed nodes cannot move, and mobile nodes can move reasonably according to needs. With the increase of the number of movable nodes, the coverage and moving distance of the nodes are also increasing. Compared with other algorithms, MAC-CMNP algorithm can effectively improve the network coverage and reduce the moving distance of the nodes. Because other mixed algorithms do not consider the combination of low-cost fixed nodes and high-cost mobile nodes, they cannot continue to improve the coverage effect of the monitoring area. This algorithm calculates the reasonable distance between adjacent nodes before the wireless sensor nodes move, so the distance between wireless sensor nodes is gradually increasing, which can avoid the round-trip invalid movement of wireless sensor nodes and reduce the unnecessary movement of wireless sensor nodes. The simulation results show that the algorithm can make the gathered wireless sensor nodes disperse gradually by reasonably adjusting the distance between wireless sensor nodes, improve the coverage effect of wireless sensor networks, and reduce the moving distance of wireless sensor nodes.

5. Conclusion and Future Work

Due to the complex structure of mobile nodes, the network cost is high after being widely used. In order to reduce the use cost of wireless sensor networks, monitoring area coverage based on control multimedia nodes position (MAC-CMNP) is proposed in this article. Due to the differences in equipment structure and use cost between fixed nodes and mobile nodes, in order to complete the monitoring task under the condition of reducing the use cost of wireless sensor networks, the number and position of mobile nodes can be reasonably adjusted according to needs to improve the effective coverage area in wireless sensor networks. In the process of adjusting the position of mobile nodes, fully consider the energy consumption of mobile nodes, avoid nodes with less energy moving too long, and prevent these nodes from failure due to energy depletion. Simulation results show that the algorithm can improve the coverage effect of mixed wireless sensor networks, reduce the mobile distance of mobile nodes, and is suitable for the mixed network environment with complex structures.

In this article, the algorithms related to monitoring area coverage in mixed wireless sensor networks are researched, the problems are found, and the solutions are proposed. Some research results have been achieved, but there are still some aspects that need to be improved.

With the rapid development of artificial intelligence and next-generation communication technology, more and more devices can be connected to the Internet of Things, and the scale and complexity of wireless sensor networks will become larger and larger. In the future research work, it is necessary to continue to carry out relevant research work from the following two aspects:

(1) The main research content of this article involves the localization of wireless sensor nodes. However, the influence of the positioning accuracy of sensor nodes on the monitoring effect is not considered in the research process. How the positioning errors in sensor nodes affect the monitoring effect of sensor nodes?

(2) The main content of this article is obtained by mathematical calculation. However, in the real physical space, most sensor nodes have errors in positioning accuracy, sensing area, monitoring effect, and so on, which is not completely ideal. In the future, a variety of different sensor nodes are used to experiment in the real physical space to improve the algorithm in this article.

Data Availability

The data used to support the findings of this research are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest in relation to this article.

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