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Research On Path Optimization Method Of Mobile Charging Energy Source Based On Wireless Sensor Network

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Abstract: At the complex problem of charging vehicle charging path in wireless rechargeable sensor network, an improved leapfrog algorithm is proposed to optimize the charging path. The charging model of mobile charging vehicle to network node is established, and the elite strategy is introduced to the leapfrog algorithm. Improvements are made to solve the charging path optimization and energy utilization maximization of the charging vehicle. The simulation results show that: through the optimization of the algorithm, an optimal path can be effectively found, and the battery energy utilization rate of the charging vehicle is improved.
Keywords: Wireless sensor network; optimal path; leapfrog algorithm; energy utilization.

1. INTRODUCTION

In a wireless rechargeable sensor network, the data collected and transmitted between network nodes consumes energy. Most of the sensor nodes are small in size, and the energy density of the battery is not high, resulting in a limited amount of power carried by the nodes, so there is node energy. Exhaustion and stop working, thus affecting the life cycle of the entire wireless sensor network. At present, many scholars have reduced the maintenance cost of the network, extended the network life cycle, and designed a fast and efficient charging method as an important research task to maintain the normal operation of the network node. The literature solves the problem of maximizing the charging service of the charging vehicle in the wireless rechargeable sensor network. The K-means algorithm is used to solve the problem. The literature uses the greedy idea to effectively solve the charging vehicle information in the wireless rechargeable sensor network. Collecting and charging path optimization problems. The literature has made an outstanding contribution to optimizing the residual energy of wireless rechargeable sensor network nodes before charging and the charging path of charging vehicles. The literature studies dynamic request-based wireless based on the study of traditional networks. Rechargeable sensor network, mobile chargingIt can transmit and collect the charging request information of the network node and complete the charging task independently. The literature considers that all wireless rechargeable sensor network nodes do not stop working due to energy exhaustion, the routing of the network node and the charging path of the charging car. Combinedly, the communication system in the wireless rechargeable sensor network and the total energy consumption minimization problem of the charging scheduling system are studied. The literature studies the dynamic request-based wireless rechargeable sensor network, which has a receivable wireless signal. The charging car of the device has a real-time charging request command of the receiving network node, and can dynamically give a corresponding charging task strategy in real time. The literature studies the charging scheduling problem of the wireless rechargeable sensor network through the wireless authentication sensing platform, in the radio frequency Within the range of the identification signal, the charging car can charge the network node.

This paper studies the wireless rechargeable sensor network in the static mode, with the energy and cycle carried by the charging car battery as a limiting condition, to maximize the energy utilization of the charging car battery, establish a charging model of a single charging car, the energy The problem of maximizing the utilization rate into the optimal path is proposed. The leapfrog algorithm based on the elite strategy is proposed to optimize the charging path, and the Matlab simulation tool is used to simulate the experiment to verify the effectiveness of the algorithm.

2. PROBLEM DESCRIPTION

2.1 Network model

The wireless rechargeable sensor network is regarded as a two-dimensional plane, and a fixed base station S is arranged to collect information of each node in the network. There are n randomly distributed sensor nodes, and the edges between any two nodes are regarded as 1 tree, one node can generate multiple tree nodes, as shown in Figure 1.

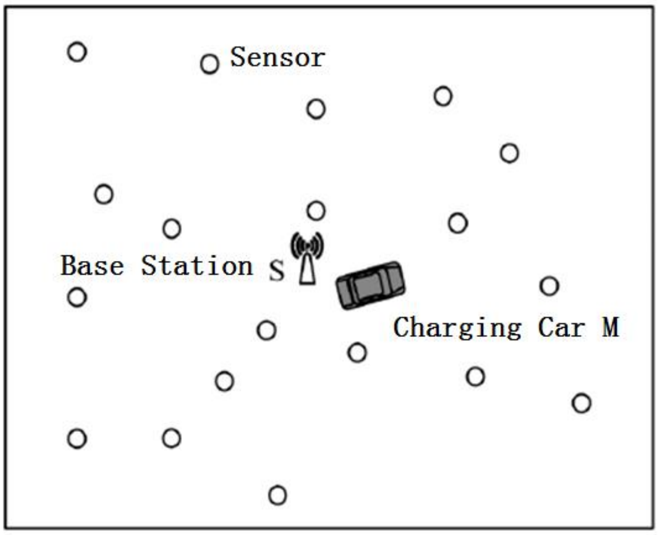

Figure 1 Schematic diagram of wireless charging sensor network

A wireless rechargeable sensor network can be viewed as a weighted undirected tree graph, represented by Z = (X, Y), where X = (x0, x1, x2, ..., xn), is a collection of n sensor nodes , Y=l(xi,xj)(i=0,1,...,n,j=0,1,...,n,i≠j) is a set of tree lengths between any two nodes, and two nodes The distance between them is the Euclidean distance dij=(yi-yj)2+(zi-zj). There is information exchange function between each node, and the detected and received data information can be transmitted to the multi-hop method. Neighboring nodes or base stations. This paper uses the energy model in the literature, assuming that the monitoring data rate of node t is ri(t)Kbit/s at any time, and the data rate sent by node xi to node xj and base station S is wij(t Kbit/s and wi, s(t) Kbit/s, the node xi receives the data rate from the node xk as wki(t) Kbit/s. When the signal transmission distance between nodes is relatively close, the self-use space model is adopted, and the path consumption index is used. 2, when the signal transmission distance is very long, the multipath attenuation model is adopted, and the path index is 4, then the energy consumed by the node transmitting the Kbit data to the distance d is

$$E_{\mathrm{Tx}}(k,d) = \begin{cases} kE_{\mathrm{elec}} + k\varepsilon_{\mathrm{fs}} d^2, & d < d_0 \\ kE_{\mathrm{elec}} + k\varepsilon_{\mathrm{mp}} d^4, & d > d_0 \end{cases} \quad (1)$$

Where: Eelec is the energy consumed to receive or transmit unit data; εfs is the power amplifier energy consumption parameter in the free space model; εmp is the power amplifier energy consumption parameter in the multipath attenuation model; d0 is the transmission of two models set in advance The threshold of the distance.

The energy consumed to receive k bits is

$$E_{\mathrm{R}x} = kE_{\mathrm{elec}} \quad (2)$$

Then the energy consumption of the sensor node xi is

$$p_i(k,d,t) = \begin{cases} k[r_i(t) + w_{i,s}(t)]E_{\mathrm{elec}} + k\varepsilon_{\mathrm{fs}} d^2 + kw_{j,i}(t)E_{\mathrm{elec}}, & d < d_0 \\ k[r_i(t) + w_{i,s}(t)]E_{\mathrm{elec}} + k\varepsilon_{\mathrm{mp}} d^4 + kw_{j,i}(t)E_{\mathrm{elec}}, & d \geqslant d_0 \end{cases} \quad (3)$$

2.2 Charging model

In the wireless rechargeable sensor network, all network nodes have a rechargeable battery as the energy receiving device, and the energy is limited. The maximum storage amount Gi, the sensor node consumes energy during the information transfer process, assuming that Emin is the node energy. The critical threshold, when the remaining energy value of the node decreases below Emin, the charging request command M, M={xi,tri,ER,pi,Gi} is sent to the base station S, where xi is the node requesting the request, and tri is the node When sending a charging request, ER is the remaining energy of the node, pi is the power consumption of the node, and Gi is the maximum storage capacity of the node energy. When the base station receives the application for charging the node, it immediately dispatches a charging car to charge the node. Until the node energy is full. If there are other nodes in the current charging process to send a charging request, the car will collect information, charge the next node in turn, and finally return to the base station to replenish energy, this is a charging schedule.

Under the premise of ensuring that all application nodes do not stop working, the energy utilization rate of the charging vehicle is maximized. The maximum energy utilization rate is equivalent to the shortest driving path of the charging vehicle during driving, and a charging model of the wireless charging sensor network is established for a single charging vehicle. As shown in Figure 2, suppose the car carries a battery with a capacity of Em, which can be used for self-driving and charging the node. The car can charge the nodes in the network in sequence, the driving speed is vc (constant speed), and the power for charging the node is pn. The power consumption during driving is pm. Since the energy carried by the car itself is limited, the maximum charging return time of the car is regarded as a charging cycle of T.

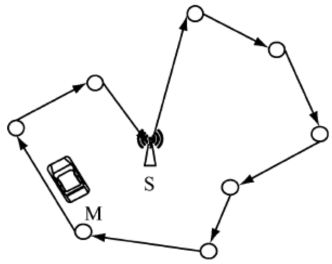

Figure 2 charging model

Considering the sensor network in static mode, it is often found that some sensor nodes are suspended due to not being charged in time, which affects the stability of the network. Therefore, this paper considers that the base station receives some node charging applications, and the car charges these nodes again. In the case of limited energy of the trolley, the charging of the required nodes is maximized, and the optimal path is selected, so that the energy utilization rate of the charging vehicle is the highest.

2.3 Maximizing Energy Utilization Formulation

Think of the sensor network as a weighted undirected tree map Z=(X,Y), the total battery energy of the charging car, Em. In the static mode, the problem of maximizing the energy utilization of the charging car is to solve an optimal problem. The charging path Dc problem, the set of nodes charged by the trolley is Vc (Vc $\in$ V), the trolley charges the node one by one according to the charging route, and finally returns to the base station to replenish energy, and maximizes the energy utilization rate of the charging vehicle battery. And the sum of the total energy charged by the charging car to the node and the energy required to drive the car cannot exceed the battery energy carried by the car itself, then the optimization target is

The constraint is

$$\min D_c = \sum_{i=0}^{c} l(x_i, x_{i+1}) \tag{4}$$

In the formula:

$$en(c) + E_c \leqslant E_m \tag{5}$$

En(c) is the sum of the energy charged by all the nodes in the charging process; Ec is the total energy consumed by the charging car during the charging process for the node.

$$en_i = G_i - E_R \tag{6}$$

Where: eni is the energy needed to charge a single node.

$$en(c) = \sum_{i=0}^{c} en_i \tag{7}$$

$$E_c = \sum_{i=0}^{c} \frac{l(x_i, x_{i+1})}{v_c} p_m \tag{8}$$

According to the above constraints, an optimal path is obtained. However, it is a difficult traveler problem to solve the optimal charging path problem of the charging vehicle. Therefore, the leapfrog algorithm based on the elite strategy solves an optimal problem. path of.

3. ALGORITHM OVERVIEW

3.1 Frog hopping algorithm

The leapfrog algorithm is a process of simulating the frog's foraging behavior. The purpose of group evolution is achieved through mutual cooperation and competition between groups. The minimum value of the function is used as an example to illustrate the basic steps of SFLA. The scale is M, and the coordinates of the i-th individual in the D-dimensional space are assumed to be: xi=(xi1, xi2, ..., xiD), calculate the individual's fitness value, then arrange from large to small, and then divide the whole population. For G local subgroups, there are N frogs in each local subgroup, and the population size represents M=G×N. In the process of descending order, the ranked individuals are evenly distributed to G local subgroups. The search is completed within the specified local iteration number Ne. If the global maximum iteration number is satisfied, the search is completed and the global optimal value is output. Otherwise, all the frogs are mixed and recalculated.

3.2 Algorithm for improving the algorithm

In the traditional SFLA, the worst frog of the local subgroup will only learn from the frog of the local subgroup. In order to make the worst frog learn from the better frogs around, the search speed is improved and the learning is improved. In the process, it guarantees its own non-degradation. And a large number of experiments show that in the process of evolution, the global optimal position will remain for many generations, making the algorithm's optimization speed slower and prone to premature phenomenon. Therefore, this paper is evolving. In the process, the Minkowski distance is introduced, so that the global optimal frog not only learns from the local subgroup optimal frog, but also learns from other frogs other than the worst frog in the local subgroup, and will go in multiple directions during the learning process. The random number that guarantees the quality of the optimal frog and accelerates the optimization speed is the learning factor of the optimal frog in the global optimal frog to other frogs and local subgroups in the local subgroup; Xi(t) is the local subgroup In addition to the worst frogs in the best frogs and local subgroups.

3.3 Algorithm solution path process

Suppose that the location, distance and energy of all the proposed network nodes are known in advance, so that the car can charge the required nodes one after another under energy constraints, and finally can return to the base station and control the travel time of the charging car at t In the meantime, the battery utilization of the charging car is maximized. The charging path is optimized by the improved leapfrog algorithm. The algorithm steps are as follows.

(1) Initialize the coordinates of n network nodes, calculate the distance between each node, and generate a distance matrix.

(2) Set the algorithm parameters to generate the initial population. Think of each frog individual in the population as a traversal path.

(3) The degree of goodness or badness of each individual frog is evaluated by the fitness function value. In this paper, the traversal path length of the charging vehicle is taken as the fitness function value.

(4) Calculate the local optimal value and the worst value, adjust the worst value, learn the worst frog from the optimal frog of other populations, and update the individual according to the formula.

(5) After the local iteration reaches the predetermined number of iterations, the local optimal value is output and compared with the local optimal value in other populations. After the global iteration number is reached, the optimal value is output, and an optimal path is obtained.

4. EXPERIMENTAL RESULTS AND ANALYSIS

4.1 Experimental environment

The wireless rechargeable sensor network designed in this paper is 100m×100m. There are 40~200 sensor nodes randomly distributed in this area. The base station S is located in the network center (50, 50). There is a mobile charging car in the network. The energy is 50kJ, the period value is 1 000s, the driving speed of the charging car is 3m/s, the charging efficiency of the charging car is 10J/s, the average power consumption of the car is 5J/s, and the maximum energy value of each node is 300J. Emin=80J of the node, the data energy consumption is 100nJ/bit, and the data energy consumption is 100nJ/bit. According to the above parameters, the simulation experiment is carried out. The simulation experiment is in the win10 system. Intel Core series CPU; 8GB memory. 500GB hard disk Simulation of MATLAB 2014b on a computer, compared with SFLA and ACSFLA. In addition, compared with Ant Colony Optimization (ACO), ACO is a behavior that mimics the behavior of ants during foraging. The idea of the algorithm is to arbitrarily select a path and leave a pheromone in the process of selecting a charging node in the charging car. The higher the concentration of the pheromone, the greater the probability that the ant selects the path, so that the optimal path is selected. Is the earlier pathIntelligent algorithm.

4.2 Performance indicators

For acsfla, this paper uses two criteria to verify the effectiveness of the algorithm, one of which is the optimization goal of this paper, and the other is the energy utilization rate. During the charging process, the total energy of the charging car charging the node and the charging process are consumed. The ratio of total energy is the energy rate.

4.3 Analysis of simulation results

Through the random distribution of the points of the network nodes, multiple simulation experiments are carried out on the 40~200 node regions. In order to make the optimal value of the solution more effective, take the average of the optimal values of multiple sets of optimizations. The following is the analysis of the simulation results. .

Figure 3 is the path distance curve of sfla, aco and acsfla after 40~200 nodes. From the curve change, sfla and acsf-la perform well when the number of nodes is small, but at the node. As the number increases, it is obvious that the result obtained by sf-la is not very satisfactory. When the number of nodes is increased to 140, the charging path of sfla is the longest, and the path solved by acs-fla is always better than the other two. short.

Figure 4 shows the variation of the energy utilization rate of the sfla and acsfla when the number of nodes is 40~200. It can be seen from the figure that with the increase of the sensor nodes, the charging car can provide charging services for more nodes. Therefore, the energy efficiency of the charging car is also constantly increasing.

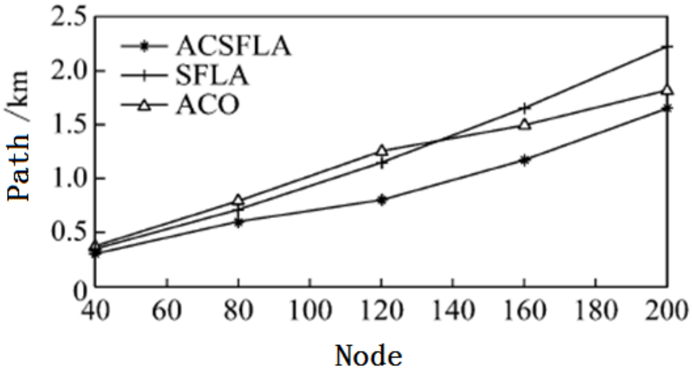

Figure 3 Optimized charging path curve

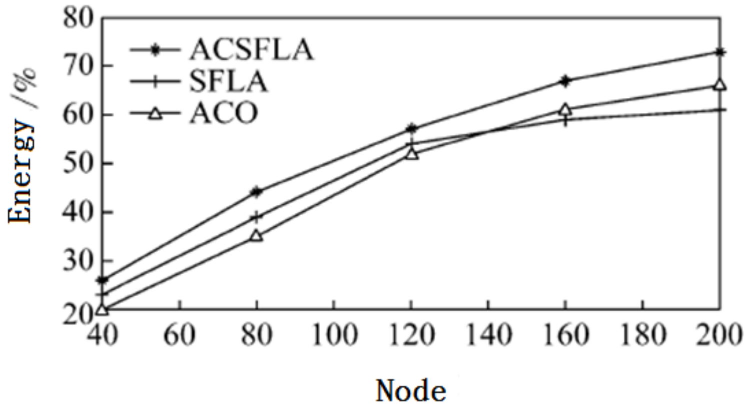

Figure 4 Energy utilization curve

When the number of nodes is small, the utilization rate of the aco-optimized charging car is the lowest. As the number of nodes increases, the curve changes gradually approach the acsfla. The optimized energy utilization ratios of the 120-node and 200-node algorithms are shown in the table. 1. When the number of nodes increases to 120, acsfla increases the energy utilization by 3.1% compared with sfla, and the aco optimization result is still not ideal. When the number of nodes increases to 200, the energy utilization of acsfla is higher than that of aco. 7.1%, and the sfla energy utilization rate is the lowest at this time. This is because the sfla is late, it falls into local optimum, resulting in low accuracy of optimization. The energy utilization rate after acsfla optimization is always higher than the other two algorithms. As described above, the effectiveness of the improved algorithm in this paper is verified.

5. CONCLUSION

In this paper, the charging scheduling problem in wireless rechargeable sensor networks is studied. Considering the actual situation, considering the limited energy carried by the charging car, the battery energy utilization rate of the charging car is converted into the shortest path in the research process, and it is optimized by acsfla. In small-scale networks, simulations were performed with sfla, aco, and acsfla. The results show that the path obtained by acsfla is the shortest and the energy utilization rate is the highest.

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