

Analysis of Energy Optimized Routing Algorithms for Improved Ant Colony in WSN

Li Chuanliang

Shandong Light Industry Vocational College, Shandong, China, 255300

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Abstract: Level routing LEACH protocol has uneven cluster head distribution, and each cluster head rotation takes place throughout the network, which will cause excessive energy consumption. However, the application of ant colony algorithm in multi-hop routing still has the problem of unbalanced energy consumption. By dividing the network nodes into regions, we can use the residual energy of the nodes as a reference factor to improve the method. By introducing node energy into transfer probability, this paper improves ant colony routing algorithm. The simulation results show that the improved algorithm can overcome the shortcomings of classical ant colony algorithm, which will achieve efficient and real-time optimal routing.

1. Introduction

WSN is a new technology produced by the cross-disciplinary application of sensor technology, microprocessor technology and wireless communication technology. WSN has many characteristics, such as distributed, low energy consumption, low cost, large-scale and so on, and allows nodes to move. WSN has many advantages, such as simple network layout, easy network expansion, good robustness and dynamic adaptability. WSN has great application value in many fields such as important military reconnaissance, traffic management, ecological environment improvement, health care and so on. At present, WSN will be one of the hot research fields in the international and domestic academic and industrial circles. Each sensor node in WSN network is an intelligent device, which can work in mobile or poor infrastructure applications. It is responsible for forwarding real-time data of message environment through the network. Each node in the network is equipped with its own power supply, which is usually a battery. So the node energy of the whole network is limited. If the sensor nodes are distributed in dangerous or remote locations which are difficult to see, when the battery energy is exhausted and cannot be replaced in time, the node lifetime of wireless sensor networks depends on its power consumption. In view of the efficient utilization of energy and considering the link characteristics, this paper proposes a WSN routing optimization algorithm based on ant colony algorithm.

2. Ant algorithm and its energy optimization routing algorithm

2.1 Ant colony algorithm

Ant colony algorithm (ACO) is a heuristic stochastic optimization algorithm proposed by M. Dorigo in 1992. It uses positive feedback mechanism to achieve distributed global optimization. The two main steps of ant colony algorithm are: selecting the next node according to probability; updating pheromone globally. Keeping ant K at node r , the probability of accessing next node s is formula 1.

$$P_k(r, s) = \begin{cases} \frac{[\tau_{ij}(t)]^\alpha [\eta_{ij}]^\beta}{\sum_{t \in allowed_k} [\tau_{it}(t)]^\alpha [\eta_{it}]^\beta}, & j \in allowed_k \\ 0, & j \notin allowed_k \end{cases} \quad (1)$$

τ_{ij} is a pheromone. η_{ij} is the reciprocal of the distance between node i and node j (path length or edge cost sum). $J_{ij}(t)$ is a collection of nodes that have not yet been accessed. β is to adjust consumption parameters and pheromone importance factor (β is generally taken as 1 or 2). The pheromone is updated globally as formula 2.

$$\Delta\tau_{ij}(t) = \begin{cases} 1/L_k, & \text{If } (t) \text{ is the edge of ant } k \\ 0, & \text{otherwise} \end{cases} \quad (2)$$

α was the volatilization degree of pheromone ($0 < \alpha < 1$). L_k is the consumption parameter for ant k to complete path finding

2.2 Improved inter-cluster routing algorithms for ant colony

The basic ant colony algorithm is applied to establish inter-cluster routing. When calculating the transfer probability of ants, we only consider the pheromone content and the length of the path from the current node to its neighbor node, but this strategy in WSN is not completely suitable for the characteristics of sensor networks. In WSN, if some nodes undertake too much data transfer task, it will consume too much energy, which will cause uneven energy consumption of nodes. Therefore, this situation will lead to premature death, which will cause the network can no longer monitor this area. If we rely on these nodes for data transmission, we will not be able to collect information to transmit to the anchor node. In order to solve this problem, this paper improves the formulas of ant transfer probability and local pheromone updating.

The area of wireless sensor network can be divided into n areas by Voronoi diagram method, and the area of the area is approximate. Through the improved LEACH protocol, n cluster heads are selected for n regions, and then we generate cluster heads in the region and connect the nodes in the cluster. By introducing the residual energy level of nodes into the basic ant colony algorithm, the improved formula is shown in Formula 3 below.

$$P_{ij}^k(r, s) = \begin{cases} \frac{[\tau_{ij}(t)]^\alpha}{E(j)^\lambda} [\eta_{ij}]^\beta}{\sum_{t \in allowed_k} \frac{[\tau_{it}(t)]^\alpha}{E(t)^\lambda} [\eta_{it}]^\beta \tau}, & j \in allowed_k \\ 0, & other \end{cases} \quad (3)$$

At the same time, the improved formulas for updating local pheromones are as follows:

$$\Delta\tau_{ij}^k = \begin{cases} \frac{Q_{global}}{\left(C - \frac{P_{min k}}{P_{avg k}}\right)} \\ 0, & otherwise \end{cases} \quad (4)$$

Among them: Q_{global} is a global constant; L_k is the sum of the distances that ant k travels from source node to specific anchor node; $P_{min k}$ is the minimum residual energy of node recorded by ant k from source node to target node in the algorithm; C is the energy level of initialization of each ordinary node; $P_{avg k}$ is the iteration process of ant k in an iteration process of the algorithm. The average of the residual energy level of all nodes in the path.

3. Experimental simulation and result analysis

In this paper, the simulation experiment of improved Ant Colony algorithm (IACA) is carried out in Matlab environment, and the WSN is built with 200 sensor nodes distributed in 200 m * 200 m area on average with the classical ant colony algorithm (ACA). The results of path comparison,

average hops and network energy consumption with the number of iterations are compared and analyzed. Table 1 is the setting of experimental environment and experimental parameters.

Table 1: Setting of simulation experiment parameters

Experimental parameters	Parametric values	Experimental parameters	Parametric values
Initial energy of nodes	1	Processing Unit Data Loss Energy	50×10^{-9}
Sink node location	(0,0)	Pheromone heuristic factor alpha	0.3
Packet size	1 000	Heuristic function heuristic factor beta	0.3
Power Amplification Factor	10×10^{-12}	Energy Influencing Factor	0.4
Power Amplification Factor	1.3×10^{-15}	Pheromone evaporation coefficient	0.1
Number of ants M	30	Q	1

3.1 Contrastive analysis of implementation paths

Fig. 1 is a random selection of ant K from Tabuk from source node (195, 189) to sink node (0, 0). Path 1 is the path of traditional ant colony algorithm, and the path number is 77 -> 92 -> 161 -> 175 -> 59 -> 147 -> 124 -> 18 -> 37 -> 172 -> 78 -> 101 -> 129 -> 1. Path 2 is an improved ant colony algorithm, the path number is 77-143-151-97-124-106-56-79-173-1. Path 1 undergoes 13 hops from (1,1) to sink node, and there are several times when ants stagnate along useless paths. However, Path 2 experienced 9 hops, which was due to the layering in the improved ant colony algorithm and limited the angle of the next hop. By synthetically measuring the remaining energy of the next hop node, the concentration of "Felomon" and the distance of dielectric energy, the path selection has a better direction.

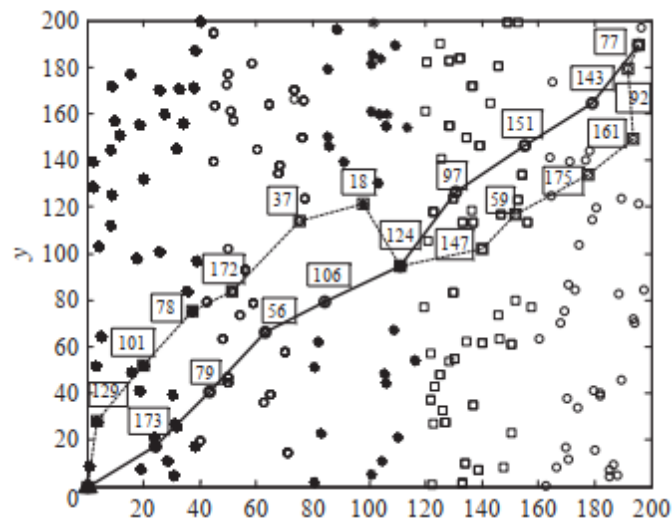


Figure 1: Path comparison between a secondary source node and a sink node

3.2 Comparative analysis of average jump number

Figure 2 shows the trend of ACA and IACA with the increase of iteration times. The two curves in the graph are as the number of iterations increases, the average number of hops decreases until it stabilizes, the average number of ACA hops tends to 13, and the improved algorithm tends to 9 hops. This shows that IACA can indeed reduce the occupation of network resources, which can reduce network routing congestion. The simulation results show that the improved ant colony algorithm can improve the efficiency of network transmission.

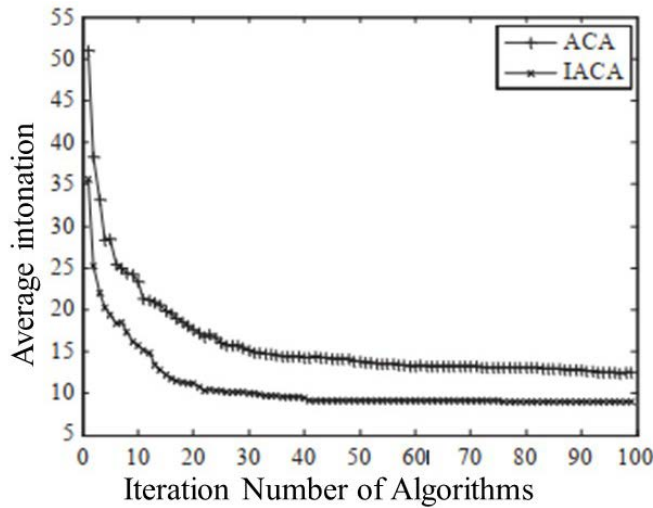


Figure 2: Average hop count comparison

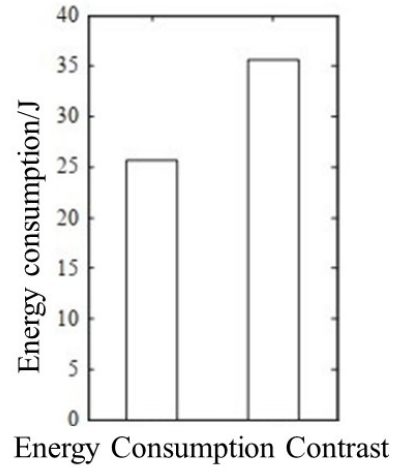


Figure 3: Energy Consumption Contrast

3.3 Comparative analysis of network energy consumption

Figure 3 shows the energy consumption of ACA and IACA algorithms when the number of iterations reaches 100. As can be seen from the graph, IACA algorithm consumes less energy than the other two groups of algorithms, which realizes the problem of reducing WSN energy consumption.

4. Conclusions

On the basis of ant colony algorithm, this paper is devoted to improving WSN routing problem by improving ant colony algorithm. The improved method avoids the problems of local premature and unbalanced energy consumption in WSN. The simulation results show that the improved ant colony algorithm improves the energy consumption and can prolong the network cycle.

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