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A Clustering Routing Protocol for Energy Balance of WSN based on Genetic Clustering Algorithm

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Abstract

Aiming at the serious energy imbalance of the traditional clustering routing, a clustering strategy for energy balance based on genetic clustering route algorithm is proposed in this paper. The new algorithm combines genetic algorithm and Fuzzy C-Means clustering algorithm, with genetic algorithm to overcome the sensitivity of the initial value of FCM. It can form the optimal cluster of network, and then select head nodes in each group. The simulation results show that compared with LEACH, the protocol can balance the energy cost of the sensor nodes, prolong the network lifetime efficiently, and perform better than LEACH.

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Keywords: wireless sensor network; energy balance; clustering; genetic algorithm; FCM

1. Introduction

Wireless sensor network (WSN)[1]is composed of a large number of these small and low-cost sensor nodes, which are randomly deployed in the sensor field and form a self-organized network system by radio communications. The sensor nodes sense, gather and transmit each kind of information of the region which is covered by the whole senor network, and then transmit it to the user. At present the application of wireless

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sensor network mainly concentrated in environmental monitoring and protection, medical care, traffic, military and other fields, especially in the marine environment monitoring system which has become the focus of research. However, sensor nodes employ mainly battery charging policy, which is hard to supply energy if they are deployed. So how to reduce the sensor node energy consumption and prolong network life is the main objective of wireless sensor network design. Among the clustering technology is one of important means which can prolong the network survival in the topology control algorithm[2].

More and more clustering routing protocol for energy balance of WSN has been presented so far. LEACH[3] is more classic clustering algorithm of wireless network than others, whose clustering thought exerts a far-reaching influence on many clustering routing algorithm proposed later. For example, LEACH-C, LEACH-F,TEEN, HEED, etc. In LEACH, we use randomized rotation of the cluster head positions to balance the energy consumption of network nodes. But its scalability is poor and this protocol offers no guarantee about the uniform distribution of cluster head nodes. LEACH-C[4]protocol selects cluster head nodes by global information. But the BS needs to know the current location of each node and the calculated amount of BS is huge. HEED[5]algorithm is totally distributed which selects cluster head by the interaction among the nodes and considers residual energy of the node in the cluster head selection process. But the algorithm has a high overhead of control message and it can't supporting the mobile nodes.

In this paper, the clustering method[6]is applied in the process of cluster of wireless sensor network, combining the local optimization ability of Fuzzy C-means clustering algorithm and global optimization ability of genetic algorithm. A clustering algorithm based on genetic clustering algorithm of WSN is proposed, which uses genetic algorithm to optimize the fuzzy clustering algorithm for the initial value sensitive issues. It can form the optimal clustering, furthermore to balance the network energy consumption and improve the performance of the network.

2. Basic theory of Fuzzy C-means algorithm and genetic algorithm

2.1. Fuzzy c-means algorithm

Fuzzy c-means algorithm (FCM)[7]clustering algorithm is a kind of clustering algorithm using membership to describe the possibility of cluster. However FCM is a local optimization algorithm, which is very sensitive to initialization and gets into the local minimum value easily.

The finite vectors x_i (i=1,2,…n) are divided into c (1<c<n) classes, and the clustering center of each class is solved to make membership minimum as the non-similarity index.

The objective function can be defined as follows:

$$J(U, c_1, c_2 ... c_c) = \sum_{i=1}^{c} \sum_{j}^{n} U_{ij}^{m} d_{ij}^2 \quad (1)$$

Where U_{ij} is the membership of the group, c_i is the clustering center, d_{ij} is the spatial distance from vector c_i to x_j. m is the weighted index.

The steps of algorithm are as the following:

- Initializing the membership matrix U to make it satisfy the following formula.

$$\sum_{i=1}^{c} U_{ij} = 1, \forall j = 1, \cdots, n \quad (2)$$

- Calculating the clustering center using the following formula.

$$c_i = \frac{\sum_{j=1}^{n} U_{ij}^{m} x_j}{\sum_{j=1}^{n} U_{ij}^{m}} \tag{3}$$

- Calculating the objective function according to the formula (1). If the objective function is less than a threshold, or the relative value function change value last time is less than a threshold, the algorithm stops.
- Updating the matrix by the following formula and returning to Step2.

$$U_{ij} = \sum_{k=1}^{c} \left(\frac{d_{ij}}{d_{kj}}\right)^{-2/m-1} \tag{4}$$

2.2. Genetic algorithm

Genetic algorithm (GA)[8]based on biological evolutionism and genetics is a kind of random searching method, developing by natural selection and evolutionary mechanism. It mainly includes three operators of choice, crossover and mutation, which both have global and local balanced search capability by means of crossover and mutation. Because of its simplicity, currency and strong robustness, genetic algorithm is used widely in optimal scheduling, data mining, combinatorial optimization and other fields.

The steps of algorithm are as the following:

- Choosing encoding methods and expressing the feasible solution as genotype string structure in the genetic space.
- Defining the fitness function f (x).
- Confirming genetic strategy, choosing the number of initial population, selection operators, cross operator and mutation operator, cross probability and mutation probability, the evolution terminate way.
- Initializing the population, calculating the fitness.
- Evolving into the next generation group by the genetic strategy.
- Judging whether it satisfies the termination conditions. If the stop condition is satisfied, the iteration ends, and the results can be encoded. Otherwise, the system returns to Step5 and repeat the procedure of iteration.

3. The clustering routing protocol of WSN based on genetic clustering algorithm

3.1. Description of the algorithm

Firstly, the protocol uses FCM based on genetic clustering algorithm (GFCM) to divide network into clusters and select cluster heads. The cluster head only accept data from cluster nodes, and then sent it to the base station after the data fusion. After working for a period of time into the next round cycle, the cluster structure is fixed. According to the principle of surplus energy situation of cluster nodes and the nearest rule in distance from the clustering center, cluster heads is reselected.

The algorithm is based on the following conditions:

- The network nodes are static.

- The geographical position of nodes is known, and the nodes have the power control and positioning function.
- Each node has equal status with the same parameters and initial energy.
- Network nodes can perform full-duplex communication, which establish direct communication with the base station.

3.2. The steps of genetic clustering algorithm

- Population initialization. Where: the scale of population is size, the max evolution generation is g, crossover probability is Pc, mutation probability is Pm. The number of cluster center is k, and geographic coordinates of each cluster center is supposed as (x_i,y_i). The binary decoding genetic chain of geographical coordinates (x_i,y_i) tandems to compose the chromosome which is initialized first.
- The following operation is made on the population:
  a. obtaining k initial cluster centers by decoding the chromosomes.
  b. Cluster division.
  c. Solving the cluster center, the membership matrix and the fitness of the current division. The original cluster center can be replaced by new cluster center which is coded into new chromosome.
  d. Calculating the fitness by the formula (5), according to the objective function.

$$f(S)=\frac{1}{J(U,c_1,c_2...c_c)} \tag{5}$$

- Select operation. Select the next generation by the proportion select method and elitist strategy according to the fitness of chromosome.
- Crossover operation. The method of single-point crossover is adopted to produce the offspring.
- Mutation operation. According to the mutation probability Pm, the "not" operator is made on the variants.
- Give the iterative times to terminate running genetic algorithm, which is the termination condition. If the termination condition is satisfied, the iteration ends, and the cluster center can be encoded. Otherwise, the system returns to Step2 and repeat the procedure of iteration.

4. The simulation experiment and result analysis

With many WSN simulation tools, MATLAB is adopted for performance analysis to the protocol. 100 nodes are randomly placed throughout the 100 m × 100 m area, shown in Figure 1(a). The base station coordinate is supposed as (0, -100), and the number of cluster centers is 5. The primary power of each node is 0.5J, and node information consumption transmitting 1 bit bytes is equal to the consumption accepting 1 bit bytes. For our experiments, E_{elec}=50nJ/bit, ε_{fs} =10pJ/bit/m^2, ε_{mp} =0.0013pJ/bit/m^4,d_0 =87m.The size of data packet is 4000 bit .In addition, the parameter value m in the fuzzy c-means algorithm is 2[9].

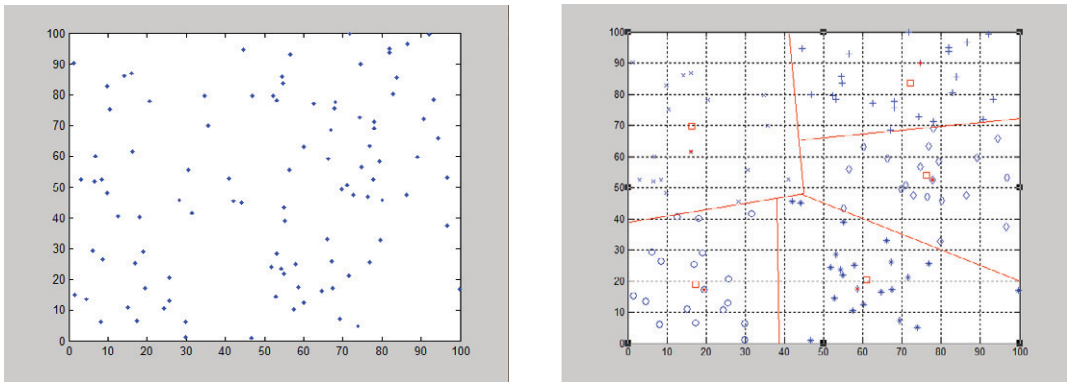

Fig 1 (a) Random distribution of nodes; (b) Clustering results of WSN

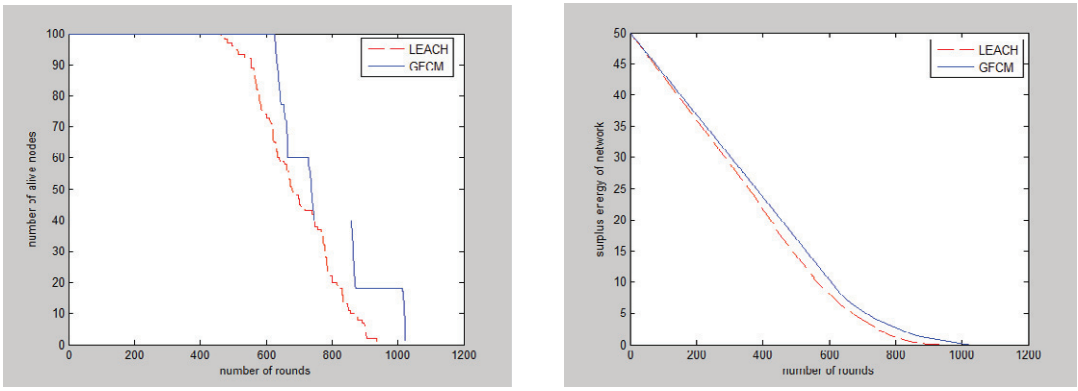

Fig 2 (a) The curve diagram of network alive nodes number; (b) The curve diagram of network surplus energy

Genetic clustering algorithm is adopted to cluster the network, shown in figure 1(b). Figure 2(a) shows the comparison between LEACH and GFCM in the number of nodes alive over time. Figure 2(b) shows the relation of network surplus energy over time using LEACH and GFCM. From figure 2(a), we can see that nodes begin to die after network works 464 rounds, and all nodes die after 940 rounds in LEACH. However, the nodes begin to die after network works 625 rounds, and all nodes die after 1023 rounds. In figure 2(b), the change trend of total energy per round in GFCM is slower than that in LEACH. The simulation results show that, compared with LEACH, the algorithm performs much better in prolonging network lifetime.

5. Conclusion

An Energy-balanced clustering algorithm for wireless sensor networks is proposed in this paper. Genetic clustering algorithm is used in the cluster process, with genetic algorithm to optimize the fuzzy clustering algorithm. It can overcome the problems that fuzzy clustering algorithm is sensitive to initial value, to optimize network clustering. The experimental results show that compared with LEACH, the protocol can effectively balance node energy consumption, reduce energy consumption and extend the lifetime of network.

Acknowledgements

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References

[1] Akyildiz IF, SuW, Sankarasubramaniam Y. Wirelesssensor networks： a survey. J Computer Networks2002;38:4-393.
[2] Wang Xiaojun, Chen Xiaoshu. A half-centralized low-energy adaptive clustering hierarchy for wireless sensor network. J Modern Electronics Technique2007;30:24-37.
[3] Al Karaki J, Kamal A. Routing techniques in wireless sensor networks: a survey. J IEEE Wireless Communications2004;11:6-28.
[4] Heinzelmn W, Chandrakasan A, Balakrislanan H. An application-specific protocol architecture for wireless microsensor network. J IEEE Transactions on Wireless Communication2002;1:4-660.
[5] Younis O, Fahmy S. Heed: A hybrid, energy-efficient, distributed clustering approach for ad-hoc sensor networks. J IEEE Transactions on Mobile Computing2004;3:4-660.
[6]Zhou Ruyan, Chen Ming, Feng Guofu. Genetic clustering route algorithm in WSN. J The 6th International Conference on Natural Computation2010;4023.
[7] Zhang Min, Yu Jian. Fuzzy partitional clustering algorithms. J Journal of Software 2004;15:6-859.
[8] Zhang Jing, Zhang Xiaogang. Data mining algorithm and its engineering application. Bei Jing: China Machine Press; 2006.
[9] Chu C H, Hayya J. A fuzzy clustering approach to manufacturing cell formation. J International Journal of production research1991;29:7-1477.