Research on Fuzzy Clustering Algorithm in Wireless Sensor Network

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Abstract: The existing clustering algorithms does not consider node belonging to each cluster of uncertain factors. Clustering decision is hard divided strictly. This paper presents a clustering algorithm based on fuzzy C mean clustering of particle swarm Optimization. The sensor nodes are divided to form different fuzzy cluster. The simulation results show that the cluster structure obtained by the proposed algorithm is stable and reasonable. The algorithm can make the network more balanced energy consumption; effectively prolong the network life cycle compared with the LEACH protocol.

Introduction

Clustering routing mechanism has become a research hotspot at home and abroad, because of its suitable for large-scale network environment, good scalability, easy management, high energy efficiency. The typical clustering routing algorithm is LEACH, HEED, TEEN, PEGASIS, SEP, EECS etc. These algorithms are designed according to the characteristics of WSNs, to solve the energy consumption constraint, adaptability and robustness problems from different angles.

The above algorithms rarely consider the topological structure of WSNs in actual application.

The logical structure doesn't match the actual distribution of nodes , leading to increased energy consumption in communication. In addition, the WSNs is easily affected by environmental factors,

when signal attenuation and noise make the sensor node properties exist a certain intermediary in the process of wireless communication, and the above algorithm of node clustering decision is used in hard division method strictly, do not consider node belonging to each cluster of uncertain factors, so lack of robustness.

Aiming at the above problems, this paper proposes a clustering algorithm based on fuzzy C mean clustering of particle swarm Optimization(CAFCPSO), the modeling process of clustering as fuzzy clustering problems of a sample space, combined with the particle swarm optimization algorithm and fuzzy C means clustering algorithm, the sensor nodes are divided to form different fuzzy cluster. Simulation results show that: CAFCPSO algorithm can get the cluster structure reasonably fast, effectively, ensure the cluster head uniformly distributed in space, compared with the LEACH dividing cluster algorithm, it can prolong the survival of WSNs cycle.

ACFCPSO algorithm

The N sensor nodes are randomly deployed in monitoring region M*M,and based on the following assumptions:

(1)The base station is fixed and located far from the sensors.

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(2) The initial energy of nodes are the same;

(3) Nodes can perceive its residual energy;

(4) Nodes can perceive its geographical position;

(5) The base station can calculate the density for each nodes around through its geographical location;

(6) The base station can calculate the distance to each node through its geographical location;

(7) Wireless communication between nodes is symmetrical.

The ACFCPSO algorithm uses the first order radio model[2]. The sensor node will send m bit data to another node with the distance of d, If the transmission distance of d is less than d0, it will use free space model, The signal power will decay in d2; else decay in d4.The sensor node will consume energy as in equation 1:

$$\mathrm{E}_{\mathrm{Tx}}(\mathrm{m},\mathrm{d}) = \begin{cases} E_{elec} * m + E_{fs} * m * d^2 & d < d_0 \\ E_{elec} * m + E_{fs} * m * d^4 & d \geq d_0 \end{cases} \qquad (1)$$

The sensor node needs to consume energy as in equation 2 receives the m bit data.

$$\mathrm{E}_{\mathrm{Rx}}(m,d) = E_{elec} * \mathrm{m} \qquad (2)$$

Fuzzy C- means clustering algorithm is very dependent on the initial value to find the optimal solution. In addition, If fuzzy C- means clustering algorithm expects a good clustering effect , it will need a lot of experiments on different initial solution, and select the better results from them, which is time-consuming and efficiency too low. Particle swarm optimization algorithm has strong global search ability, is not easy to fall into the local area, the convergence speed is fast, the combination of the two is likely to get a good clustering algorithm[3]. In the use of particle swarm optimization algorithm to improve fuzzy C- means clustering algorithm, particle swarm position is a set of cluster centers. The PSO algorithm combined with fuzzy clustering algorithm, the solution is as the initial value of FCM algorithm by using particle swarm optimization algorithm. It uses FCM algorithm to find the global optimal solution for further use. This paper puts forward a fuzzy clustering algorithm based on particle swarm optimization. The process of algorithm[4] is as follows:

(1) initialize the particle swarm's position and velocity;

(2) using $w_{ij} = 1 / \sum_{k=1}^{c} \left(\frac{d_{ij}}{d_{kj}} \right)^{\frac{2}{m-1}}$ to calculate the membership function of wij;

(3)the use of fitness function $F = \frac{1}{J_m(W,P)}$ is calculated for each particle's fitness value;

(4) compared the fitness of each particle and the experienced best position of the Pbest, if the current value is better, then the current value as its best position;

(5) compared the fitness of each particle and global best position of the Gbest, if the current value is better, then the current value as the global best position;

(6) according to the formula 1 and formula 2 to update the particle's speed and position;

(7) if the convergence conditions are met, then the end; otherwise, go to (2).

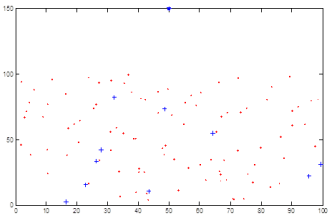
Simulation Experiments

Experimental parameters

Table 1 simulation parameters table

parameter	value	parameter	value
Regional network	100*100	The free space model (Emp)	0.0013pJ/bit/ /m2
Sensor node number (N)	100	Multipath fading model (Efs)	10pJ/bit /m4
The Sink node position	(50,150)	Data fusion energy (EDA)	5nJ/bit/signal
The cluster head expected probability (q)	0.1	The control packet size (cPL)	200bit
The initial energy of node (E0)	0.5J	The packet size (PL)	4000bit
The reception or transmission of energy consumption (Eelec)	50nJ/bit		

Analysis of simulation results



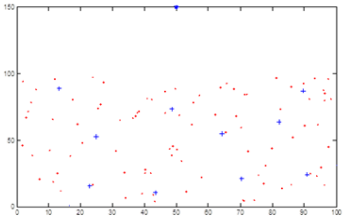
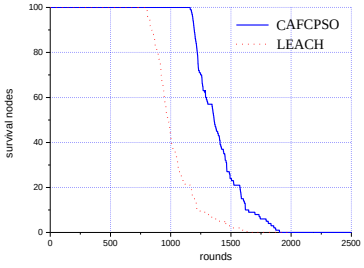


Fig.1 The cluster head election results of LEACH Fig. 2 The cluster head election results of CAFCPSO

Fig.2 is a cluster head using CAFCPSO to generate in the first round of distribution of sensor nodes in the same cluster head, compared to LEACH, not only the number of close to the optimal number of cluster heads, and corresponds to the position of the node density distribution. CAFCPSO is more uniform and reasonable.



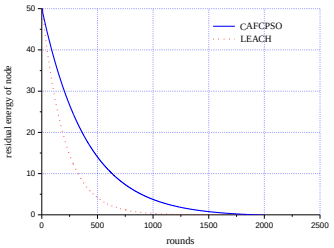


Fig. 3 survival nodes - rounds diagram Fig.4 residual energy - rounds diagram

Fig.3 compares the whole network life cycle of LEACH with CAFCPSO. In the LEACH protocol, the first node dies in the 803rd round , and the last node dies in the 1631st round ,while in the CAFCPSO protocol, the first node dies in the 1002nd round., and the last node dies in the 1984th round. When 10%, 50%, 80%, and 100% nodes of death, the survival of CAFCPSO cycle number of rounds about better than LEACH 30.2%.From the overall trend of change curve, the death rate of alive nodes in CAFCPSO protocol is slower than the LEACH protocol. In the process of survival nodes from 100 to 70, death rate of CAFCPSO is slower than LEACH about 53%.

Fig.4 shows the residual energy of LEACH and CAFCPSO. From the above chart, it is easy to find that the residual energy of network using CAFCPSO protocol is higher than using the LEACH protocol after the same number of rounds. Through the 200 round, 500 round, 1000 round of cycle,

the residual energy of network using the CAFCPSO protocol is the average using the LEACH about 5.04 times.

Conclusion

Sensor nodes is not uniform distribution and it is difficult to avoid environmental disturbance. These factors must be considered in the clustering algorithm. The clustering process modeling of WSNs is as fuzzy clustering, this paper presents a clustering algorithm based on fuzzy C mean clustering of particle swarm Optimization. The sensor nodes are divided to form different fuzzy cluster. The simulation results show that the cluster structure obtained by the proposed algorithm is stable and reasonable. The algorithm can make the network more balanced energy consumption, effectively prolong the network life cycle compared with the LEACH protocol.

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