# Improved PSO clustering routing algorithm for WSN

**Minsheng Tan, Huan Zhou*, Yangwei Li, Jianxue Liu**

*School of Computer Science and Technology, University of South China, Hengyang Hunan, 421001, China*

*Received 1 March 2014, www.tsi.lv*

**Abstract**

For cluster head selection randomness of clustering algorithm, and PSOC algorithm were not considered the distance from cluster head to base station, an improved particle swarm optimization (I-PSOC) routing algorithm was brought out. The improved algorithm particle swarm fitness function was improved by considering the node residual energy, nodes' distance and the distance between nodes and base station. At the same time, the optimal nodes were selected as the cluster head and the cluster head has transmitted the data to base station in a single or more jumps through searching right path in the improved algorithm. The simulation results show that the nodes energy consumption of network was reduced significantly and the network life cycle was extended

*Keywords:* PSO, Clustering Routing Algorithm, cluster head, Wireless Sensor Network

## 1 Introduction

Wireless Sensor Network (WSN) is relatively large-scale, and has the distribution density of numerous nodes, especially limited energy of sensor node. Therefore, the overall energy consumption of the network must be considered to achieve efficient data transfer, extending the network lifetime. For large-scale WSN, generally being used cluster-based routing algorithm, the network is divided into different clusters, select the cluster head for data integration, and reduce data redundancy [1] is a method for effectively reducing network energy consumption, enhancing network robustness and scalability, and prolonging network lifetime.

The execution of cluster-based routing algorithm is generally divided into four steps: cluster head selection, formation of clusters, intra-cluster and inter-cluster communication. Cluster head nodes not only receive and fuse the date transmitted from other nodes, but also transmit the processed data to the distant station in the same time. So it needs to consume more energy. However, most clustering algorithms used with equal probability select cluster head randomly without taking into account the energy and location information of cluster head, which leads to uneven distribution of cluster head in the network, imbalance in network energy consumption, energy consumption of data communication, premature node death, impact on the entire network life cycle [3].

Particle Swarm Optimization (PSO) is a swarm intelligence optimization algorithm and a community-based collaborative random search algorithm [4, 5], developing by simulating birds foraging behaviour. It has fast search speed, high efficiency, simple algorithm. First, a group of particles is initialized, and then search out the global optimum target area by their own experience and social collaboration. Research shows, PSO find the global optimal solution with relatively high probability and accuracy, so it can be applied to the WSN which has numerous nodes and limited energy for cluster head selection. In this paper, it mainly optimizes the selection of cluster head in clustering routing by improving fitness function, thus, forming the optimal cluster, minimizing sensor node energy consumption, extending the network lifetime [6-8].

## 2 Analysis of PSO clustering routing algorithm

### 2.1 PSO INTRODUCTION AND PROCESS

PSO is to solve optimal problems by simulating birds foraging behaviour. Every bird is abstracted as a "particle", and has its own position and velocity to determine the search direction and distance, as well as a value of fitness function to measure particle properties. It initiates a group of particles firstly, and then particles find the global optimal solution in the search space by iteration. Suppose: the community size is M; the *i*-th particle in the search space is defined as $X_i = (x_{i1}, x_{i2}, ..., x_{im})$ ; the particle velocity is defined as: $V_i = (v_{i1}, v_{i2}, ..., v_{im})$ ; the optimal location searched by particle i can be expressed as $P_i = (p_{i1}, p_{i2}, ..., p_{im})$ ; the current optimal location in the group can be expressed as $P_g = (p_{g1}, p_{g2}, ..., p_{gm})$ . Each iteration particle updates the information of position and velocity by tracing $P_i$ and $P_g$. The Equations for updating information of position and velocity are following:

$$V_{id}(t+1) = \omega V_{id}(t) + c_1 r_1 (P_{id} - X_{id}(t)) + c_2 r_2 (P_{gd} - X_{id}(t)) \quad (1)$$

**Corresponding author's* e-mail: tanminsheng65@163.com

$$X_{id}(t+1)=X_{id}(t)+V_{id}(t+1)\,. \quad (2)$$

Parameters and description in the above Equation are shown in Table 1.

TABLE 1 Update the parameters and describe the Equation

| | |
|---|---|
| $V$ | Velocity of particle |
| $X$ | location of particle |
| $t$ | Number of iteration |
| $\omega$ | Weighting coefficient |
| $c1$,$c2$ | Factor of studying |
| $r1$,$r2$ | Random Num in(0,1) |
| $P_{id}$ | extreme value of Every particle |
| $P_{gd}$ | extreme value of Every particle |
| $i$ | The positive integer between [1,M] |
| $d$ | The positive integer between [1,D] |

In Table 1, $P_{id}$ is Individual optimum solution and extreme value of every particle, $P_{gd}$ is all particle group's optimum solution and extreme value of every particle, M is the amount of the particle, D is the biggest dimension in searching zoom.

PSO process is as shown in Figure 1. Its basic steps are following as:

1) Initiate particles, every particle has velocity $V_i$ and position $X_i$, set the number of iterations as $K$, and the learning factors as $c1$ and $c2$.

2) According to the fitness function, figure out each particle fitness function value, the compare with $P_{id}$ and $P_{gd}$, update individual and global optimal solution.

3) Update particle velocity and position by the Equations (1) and (2).

4) Until the end of iterations, repeat the steps (2) and (3).

In large-scale WSN, routing algorithms are used to adopt clustering methods. While PSO mainly optimize the cluster head selection for clustering algorithms and form optimal cluster, and then balance network energy consumption and prolong the network lifetime.

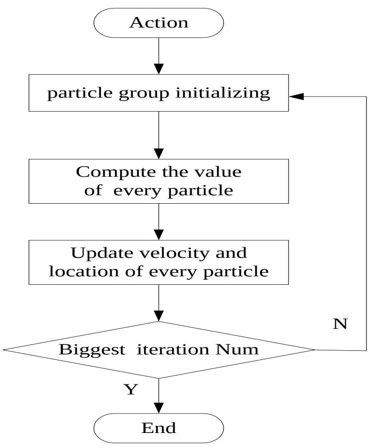


FIGURE 1 Particle swarm algorithm flow chart

## 2.2 CLUSTERING ALGORITHM

LEACH algorithm is a low-power, self-organizing adaptive clustering routing algorithm. Its execution is cyclical, and it involves two phases in every cycle: establishment of clusters and stable data transmission. LEACH algorithm randomly selected cluster head, so the probabilities of each node becoming a cluster head are equal. This makes the energy consumption of each node is relatively balanced, and then prolong the network lifetime. The two stages process is as follows.

### *2.2.1 Establishment of clusters*

The sensor node generate a random number during [0,1]. Set the threshold as $T(n)$. If node has be selected as cluster head, $T(n)$ is 0, and can't be cluster head any more. While unselected nodes will be elected with equal probabilities $T(n)$. $T(n)$ calculate is as follows:

$$T_{(n)}=\begin{cases}\dfrac{p}{1-p\cdot(r \bmod \frac{1}{p})} & n\in G\\ 0 & Other\end{cases}\,. \quad (3)$$

In the Equation (3) $P$ is the proportion of cluster head odes number in the network as whole, $r$ is cycles, $r$ *mod* $(1/p)$ is the nodes number. These nodes have been cluster head, $G$ is a set, expressing all unselected nodes in the current cycle.

After selecting cluster head, the cluster head node should inform other non-cluster head node by releasing messages. These nodes select and join to the cluster, which the nearest cluster head belong to, while sending the message to inform its selected cluster head. After all member nodes send messages to inform the cluster head, the cluster head will establish TDMA slot table and broadcast messages to inform all members. Thus, all nodes can send data in each time slot and avoid conflicts when intra-cluster nodes are working.

### *2.2.2 Stable data transmission*

The network will enter a stable data transmission phase after clusters establishment end. Intra-cluster member nodes send the collected monitoring data to the cluster head in its own distributed time slot. Member nodes will be in a sleeping state to save energy during some time that its own time slot is yet to come. While cluster head will always be in working state, sending the data is processed through the fusion to the base station. To avoid signal interference between nearby clusters, different intra-clusters all member nodes can adopt different coding way of CMDA. LEACH algorithm process is described on Figure 2. The algorithm has the following advantages:

1) Randomly select cluster head nodes with equal probability. Relatively balance overall network energy

consumption, save energy, avoid excessive energy consumption of nodes to death and prolong the lifetime of the node.

2) The entire network is divided into multiple clusters, and data communication is involved the intra-clusters and the inter-cluster. So it is more suitable for large-scale WSN.

3) Cluster head fuses the data transmitted from others, and sends them to the base station. Then reduce data redundancy of transmission.

4) Intra-cluster all member nodes has a sleep mode. It will be working condition only when send or receive data.

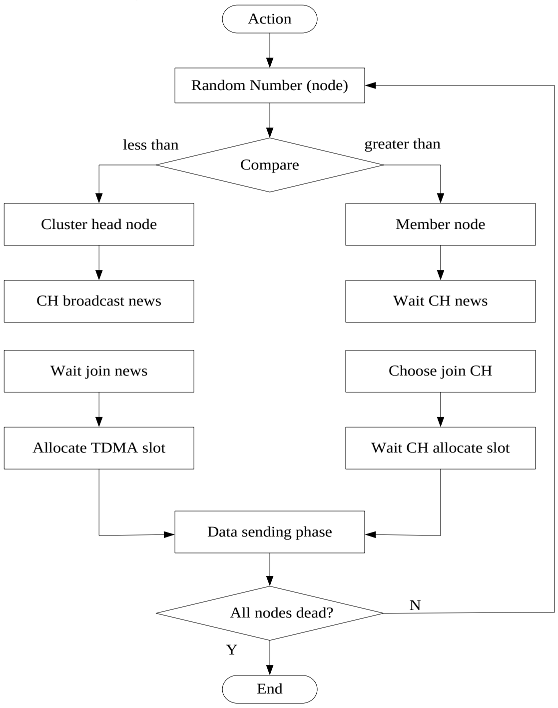


FIGURE 2 Flow chart of the LEACH algorithm

But there are also many disadvantages of LEACH algorithm:

1) Not take into account the position of the cluster head.

2) Not take into account the residual energy of cluster head, cluster head need greater energy consumption for conducting data fusion.

3) Communication between cluster head and sink node use single-hop routing. When aggregation node farther away from the cluster head in the cluster, because of excessive power consumption will prematurely die, and then affect network connectivity.

4) After the network operates stably for a period of time, a new cycle cluster head selection should be conducted again.

### 2.3 DESIGN REQUIREMENTS OF PSO CLUSTERING ROUTING ALGORITHM

In the design of particle swarm clustering algorithm, we must take into account the following aspects:

1) With an appropriate fitness function, the fitness function setting has an important impact on the algorithm.

2) With the appropriate updating algorithm, to update the particle velocity and position information.

3) With adjustable optimization parameters, make the results do not deviate from the correct solution.

Many scholars at home and abroad research PSO algorithm to implement network optimization clustering problem. In spite of the particle swarm optimization algorithm has many advantages, but there are also easy to fall into local optimum. We mainly improve the parameters of the fitness function in algorithm, the topology structure, the inertia weight, learning factors and mixed strategy, such as paper 47 28 49 and 50, of which more representative is 50 PSOC algorithm, effectively balance the network energy consumption, although it considers the nodes energy and the distance between nodes within cluster, but it without considering the effect of cluster heads and base station distance. If the distance is larger, cluster heads are very easy to premature deaths due to energy consumption too fast.

This article, mainly, improve the situation aimed at selecting cluster heads random in clustering algorithm and PSOC algorithm problems.

## 3 Improvement of particle swarm cluster routing algorithm

### 3.1 ALGORITHM IMPROVEMENT SCHEME

Firstly, network has been divided into different clusters by using clustering algorithm, set a threshold energy, and then form a candidate cluster heads set, then combined with improved fitness function, according to the candidate set of cluster heads within each node's residual energy and location, using PSO algorithm, select the global optimal node as the cluster head, cluster heads broadcast information, transmit and receive within the cluster node's residual energy and location information, and to establish a time slot table, for each of the distribution of cluster nodes when the TDMA slots. The main function of Cluster member nodes is testing the object of data collection, and transmitting data to the cluster head, cluster heads not only collect the data, but also transmit the data fusion in the cluster member nodes, finally, through single hop or multiple hops they send the date to the base station (gathering node).

The method can efficiently prolong the network life cycle, the network node have the opportunity to become a cluster head when the network node energy is higher than the energy threshold set. if the cluster head suddenly die or energy is lower than the threshold, the network node will be back for cluster heads selection, The shortage for clustering algorithms when it used data transmission in one hop paths which lead to far from the base station of the premature death of cluster nodes, in the data communication stage, the cluster heads sent to the distances from the base station or base station of cluster nodes in the cluster based on decision fusion data. Cluster heads choose the appropriate path to base station. This method can effectively reduce the network energy consumption and prolong the network life cycle.

### 3.2 NETWORK MODEL

Network model of this paper is shown in Figure 3, and the research of wireless sensor network makes the assumption.

1) Node and base station position is fixed, base station far away from node distance, cluster heads selection is not affected by the environment.

2) The nodes know their position information and residual energy.in addition to the base station, the rest of the initial energy of nodes and processing power are equal, the same communication range.

3) The node transmission power can be adjusted according to the communication distance.

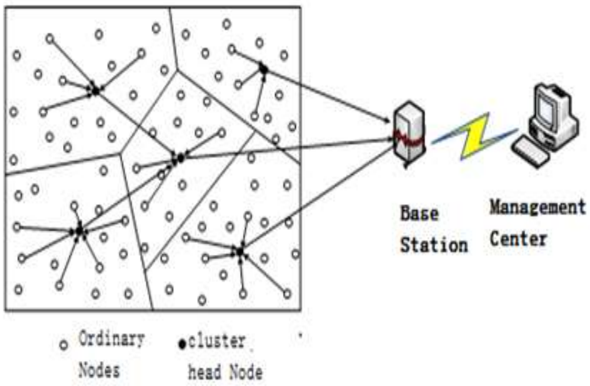


FIGURE 3 The structure of the network

### 3.3 ENERGY MODEL

In this paper we use the first-order energy consumption of wireless communication model, as shown in Figure 4. The model is based on the following assumptions:

1) The node energy limited.

2) The node energy consumption is basically the same.

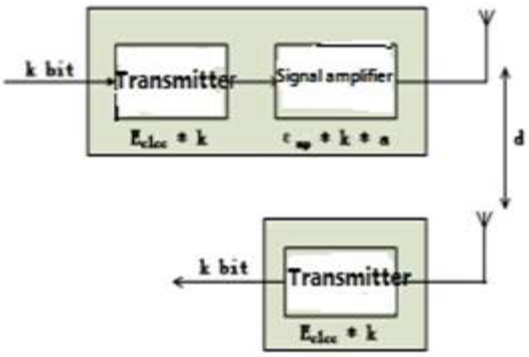


FIGURE 4 Wireless communication energy model

Form of the energy consumption according to the attenuation of power amplifier can be divided into two parts: free space model and the multipath attenuation model. Attenuation model, power amplifier based on node spacing selection for d0 set threshold method, the distance between nodes is d, if d < d0, multipath attenuation model is adopted, therefore, when Kbit node transmission data information, the energy consumption between sensor nodes can be represented as:

$$E_{Tx}(k,d)=\begin{cases}E_{elec}\cdot k+\varepsilon_{fs}\cdot k\cdot d^2\,(d<d_0)\\ E_{elec}\cdot k+\varepsilon_{mp}\cdot k\cdot d^4\,(d\ge d_0)\end{cases}. \quad (4)$$

$$E_{Rx}(k)=E_{elec}\cdot k \quad (5)$$

Among the equation above, the $E_{Tx}(k,d)$ represents the energy consumed by the transmission of *k* bits data, the $E_{Rx}(k)$ represents the energy consumed by the reception of *k* bits data, the $E_{elec}$ represents the energy consumed by the transmission of 1 bit data, respectively, $\varepsilon_{fs}$ and $\varepsilon_{mp}$ represent the power amplifier circuit to model consumption coefficient of multi-path model and the free space attenuation, *d* is the distance that data transmitted, $d_0$ is the threshold distance set.

### 3.4 IMPROVEMENT OF FITNESS FUNCTION

Evaluate the quality of the selected cluster head based on the fitness function, we mainly consider the three aspects of content. Firstly is the cluster head energy evaluation factor $f_1$. Cluster energy takes the inverse proportion of the total energy $S_f$ the nodes within the cluster. Cluster heads should not only accept the quantity of node data but also transmitted the data to base station. The largest energy consumption, therefore, cluster heads residual energy is larger, the better. Secondly, evaluation factor $f_2$, stand for the average distance of the node to the cluster head, the smaller the average distance, the less data transmission energy consumption between nodes. Thirdly, evaluation factor $f_3$, stand for cluster heads to the base station distance, the smaller the best path to the base station, the smaller consume energy cluster head used, hypothesis, network consists of M nodes, divided into k clusters, the improvement of fitness function is as follows:

$$f=\alpha f_1+\beta f_2+\gamma f_3, \quad (6)$$

$$f_1=\sum_{j\in(C_i)}E(n_j)\Big/E(CH_i), \quad (7)$$

$$f_2=\sum_{j\in(C_i)}d(n_j,CH_i)\Big/|C_i|, \quad (8)$$

$$f_3=\min_{k=1,2,\dots,K}\{d(CH_i,BS)\}. \quad (9)$$

According to (6), it calculates particle fitness function value, select the global optimal node as the cluster head. Fitness function value is smaller, the residual energy of the cluster heads is much more or the distance between the cluster member nodes and cluster heads is closer, the distance between cluster and the base station is closer.

### 3.5 DETAILED STEPS OF ALGORITHM IMPROVEMENT

Network nodes could be divided into different clusters, this paper uses PSO algorithm to select the global optimal node as the cluster head, and find the optimal cluster. The cluster heads through single hop or multiple hops, and then transmit data after fusion methods to the base station and balance network energy consumption and prolong the network life cycle. I-PSOC algorithm in this paper and the cluster head selection cycles, each cycle is divided into clusters of establish and stability of the data transmission phase. Include the cluster initialization of the candidate, according to the improvement of the fitness function to select the optimal cluster heads and the formation of optimal cluster; Data transmission phase including the cluster-heads data transmission and data transmission between clusters. Its algorithm steps are as follows:

**Step 1.** Initialize clustering of network, set up energy threshold $E_T$, when the node energy is greater than $E_T$, it have a chance to become cluster head. Assume the $CH_{candidate}$ represents the set of candidate cluster:

$$CH_{candidate} = \{n_i \mid E_i > E_T\},$$

and the $E_T = \sum_{i=1}^{M} E_i \Big/ M$.

$E_i$ represents the remaining energy of current node, $M$ represents the total number of nodes in the network. Although, determined the candidate cluster head basically at this stage, only consider the residual energy, ignoring the wasted energy that cluster head caused for the uneven distribution, therefore need to improve the fitness function, select the optimal cluster head from the candidate cluster head collection.

**Step 2.** Improve the fitness function, select the optimal cluster head. Initialize candidate of cluster particles, calculate the particle's fitness, adopt iterative method to update particle's speed and position, until the cessation of reaches maximum number of iterations of the algorithm, the global optimal solution will become the cluster head.

Basic steps are as follows:

**Step 1.** Initialize the particle swarm. initial speed and position of particles in the candidate set of cluster heads, calculate each particle's fitness by the Equation (6), and initialize the particle position as the individual optimal solution P, choose to adapt the value of the smallest particles as the global optimal solution of the whole particle P1.

**Step 2.** Update the particle's position and speed. According to the Equations (1) and (2) get each particle's new position and speed, and calculate a new adaptive value $f_1$ by the Equation (6).

**Step 3.** Update the individual optimal solution. Compare the *i*-th particle current fitness fi and individual optimal solution P. If $f_i$ < P, it updates the P, on the other hand, keep P.

**Step 4.** Update the global optimal solution. Compare the smallest individual optimal solution in the particle swarm and the initial global optimal solution of the whole particle swarm P1. If less than P1, the individual optimal solution of particles become the global optimal solution of the whole particle P1, otherwise, keep P1.

**Step 5.** Repeat steps (2), (3) and (4), until the maximum number of iterations, and then end of the recycle. Select the global optimal solution as the cluster head.

Algorithm process is shown in Figure 5.

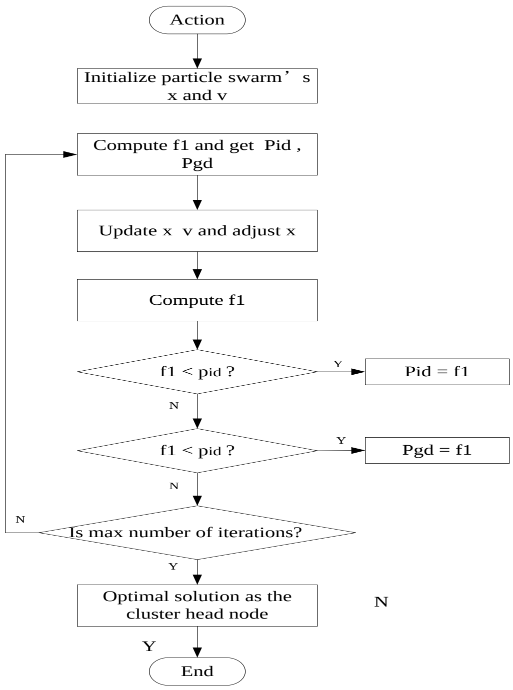


FIGURE 5 Improved cluster heads selection algorithm

### 3.6 THE FORMATION OF OPTIMAL CLUSTER

After using the I-PSOC algorithm to select cluster head, each node choose to join the cluster according to the sent message signal strength when it receives, and sent its energy and location information to cluster heads. The cluster head nodes allocated time slot for each members. Stable data transmission phase:

1) Data transmission phase in the clusters. After form optimal clusters, cluster member nodes will collect data transmission to the cluster head in its own slot, the rest of the time it dormant to save energy.

2) Data transmission between clusters. The stage mainly is cluster head accept the members of cluster nodes transmit data and fusion, and then choose the appropriate path to transmit data according to the distance of cluster heads to the base station.

Limited distance value d0, and generally take the average distance of the cluster heads to the base station. If the distance from the base station to cluster head d>d0, then the cluster head search the optimal path for transmitting the merged data to the base station by the multi-hop way. Else d<d0, cluster head will be directly to transmit the merged data to the base station by the single-hop way.

When the node and the base station are fixed, this cluster head selection process is not affected by environmental factors. If the cluster head energy is below the energy threshold $E_T$, then re-select for cluster head. The selected node as the cluster head global optimal way, balancing the network energy consumption, thus effectively extending the network life cycle.

## 4 Simulation and result analysis

### 4.1 THE PERFORMANCE OF I-PSOC ALGORITHM EVALUATION INDEX

In this paper the improved routing algorithm evaluation mainly consider the following aspects: network life cycle, the network energy consumption.

1) Network life cycle can be expressed as the relationship between the number of nodes in the network and the survival time (number of rounds) of running.

2) Energy consumption of the network can be expressed as the energy of all nodes in the network over time, of the remaining amount of energy consumed.

### 4.2 SIMULATION ENVIRONMENT AND PARAMETER SETTINGS

To verify the improved performance of the algorithm, use TOSSIM tools for simulation, to carry out large-scale network simulation, to imitate the behaviour of the hardware resources, through to the hardware simulation component changes, can provide a variety of different hardware environment performance, meet the requirements of different users.

TABLE 2 Energy simulation parameters

| Parameter | Value |
|---|---|
| $E_{abc}$ | 50nJ/bit |
| $E_{DA}$ | 50nJ/bit/singal |
| $\varepsilon_{\varepsilon}$ | 10pJ/bit/m$^2$ |
| $\varepsilon_{mp}$ | 0.0013Pj/bit/m$^4$ |
| $E_0$ | 0.5J |
| Package's length | 4000bits |

In this article, through TOSSIM simulation tools from two aspects of the network life cycle and the network energy consumption compared with LEACH and PSOC algorithm Using Figure 4 wireless communication model and energy consumption is calculated using the Equation (4). Simulation environment: the 100 sensor nodes randomly distributed within the 100x100m square area, the base station is located in (= 50 X, Y=150). The simulation parameters are shown in Table 2. The parameters of the particle swarm optimization algorithm for: α=0.35, β=0.35, γ=0.3, ω=0.9, learning factor c1=2, c2=2.

### 4.3 EXPERIMENT AND RESULT ANALYSIS NETWORK LIFE CYCLE COMPARED

The I-PSOC algorithm simulation, record and with LEACH algorithm and PSOC compare the amount of surviving nodes. Suppose among the node does not appear data retransmission and the phenomenon of transmission errors, and the members of the cluster nodes without transferring data in a sleep states. Simulation in this paper, a total of 750 rounds, discrete simulation get round number and node number offered as shown in Tables 3 and 4.

TABLE 3 The relations between total number of rounds and surviving nodes

| Rounds surviving nodes | 0 | 100 | 200 | 300 | 400 |
|---|---|---|---|---|---|
| LEACH | 100 | 100 | 100 | 95 | 80 |
| PSOC | 100 | 100 | 100 | 100 | 90 |
| I-PSOC | 100 | 100 | 100 | 93 | 85 |

TABLE 4 The relations between total number of rounds and remaining energy

| Rounds surviving nodes | 500 | 600 | 650 | 700 | 750 |
|---|---|---|---|---|---|
| LEACH | 52 | 20 | 0 | 0 | 0 |
| PSOC | 68 | 40 | 20 | 0 | 0 |
| I-PSOC | 75 | 49 | 33 | 16 | 0 |

Surviving nodes in the network and simulation rounds relationship shown in Figure 6. The simulation results show that compared with LEACH and PSOC algorithm, with the number of rounds progressed, the I-PSOC algorithm in the number of surviving nodes significantly more. PSOC algorithm is not survive more node than the I-PSOC algorithm, but still want to survive more than LEACH algorithm nodes, if all node dies, the I-PSOC algorithm in the network experienced a number of rounds is clearly more than LEACH and PSOC algorithm, It can be seen, the paper improved PSOC fitness function selected as the cluster head global optimal solution, compared to LEACH algorithm randomly selected cluster head and PSOC algorithm does not consider the distance between cluster head and the base station method, network significantly less energy consumption, extended lifetime effectively.

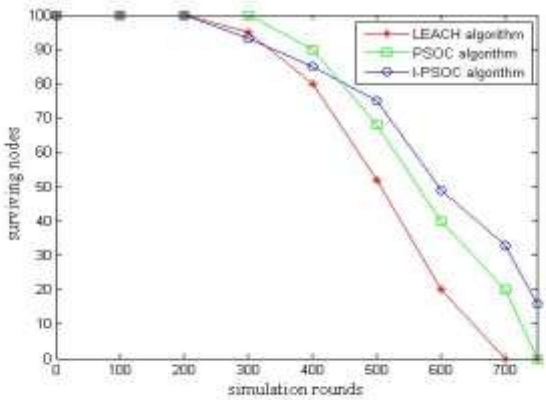


FIGURE 6 Network life time contrast

## 4.4 NETWORK ENERGY CONSUMPTION COMPARED

On improved particle swarm routing algorithm simulation, record the total residual energy of network nodes, and with LEACH and PSOC algorithm total residual energy of network nodes for comparison. This co-simulation 750, discrete number of rounds simulated node residual energy relationship shown in Tables 5 and 6.

TABLE 5The relations between total number of rounds and remaining nodes

| Rounds remaining energy | 0 | 100 | 200 | 300 | 400 |
|---|---|---|---|---|---|
| LEACH | 50 | 47 | 42 | 35 | 27 |
| PSOC | 50 | 48 | 44 | 38 | 32 |
| I-PSOC | 50 | 48 | 45 | 40 | 34.5 |

TABLE 6 The relations between total number of rounds and remaining energy

| Rounds remaining | 500 | 600 | 650 | 700 | 750 |
|---|---|---|---|---|---|
| LEACH | 17 | 6 | 0 | 0 | 0 |
| PSOC | 25 | 15 | 8 | 0 | 0 |
| I-PSOC | 28 | 19 | 14 | 7 | 0 |

Network nodes remaining energy relations with simulation round number is shown in Figure 7. The simulation results show that when going through the same number of rounds, the I-PSOC algorithm in network nodes significantly more total residual energy, PSOC algorithm followed, LEACH algorithm in network energy consumption the most. Therefore, the I-PSOC algorithm can effectively prolong the network lifetime. That is the cluster head selection algorithm in the first set when an energy threshold, the candidate cluster head constitute a collection through I-PSOC fitness function, selection from the candidate set of cluster heads the global optimal solution as the cluster head, forming optimal clusters. While inter-cluster communication, also set a distance d0, if the distance between the cluster head and the base station is smaller than d0, transmit data in a single jump directly, else, the cluster head will search for the most suitable path to transmit the merge data to the base station by multi-hop way, effectively balancing the network energy consumption and prolong the life cycle.

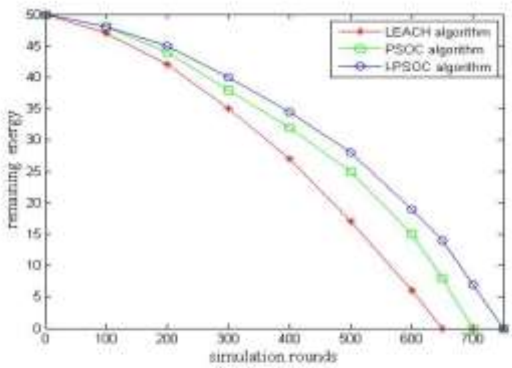


FIGURE 7 The remaining energy of nodes in the network contrast

## 5 Conclusions

This paper first introduces the basic principles of particle swarm algorithm and algorithm-step process, and made a careful analysis of particle swarm clustering routing algorithm. Then according to the clustering algorithm of cluster head selection of randomness and PSOC algorithm does not take into account the distance cluster head and base station, etc. From the node residual energy distance between nodes and the node and the base station distance to consider, improved particle swarm fitness function, select the globally optimal node as the cluster head, forming optimal cluster. Meanwhile, the intra-cluster communication using single-hop transmission of data, the inter-cluster communication from the base station in accordance with the distance of cluster heads choose the right path (single-hop or multi-hop) to transfer data to a base station. Finally introduces TOSSIM discrete simulation tools, build a simulation environment, set energy consumption parameters and use TOSSIM simulation tools. From two aspects of the network life cycle and energy consumption to evaluate the performance of the I-PSOC algorithm, compared with LEACH and PSOC algorithm simulation results, analysis shows that the I-PSOC algorithm significantly reduces the network energy consumption, effectively prolong the network life cycle.

## Acknowledgements

This work was supported by Project 61300234 of the National Science Foundation of China, the construct program of the key discipline in University of South China, the construct program of the key laboratory in University of South China, Project 2012KG71 of the Hengyang City Science and Technology Plan, key Project 14A121 of the Hunan Provincial Education Office Science Research of China.

## References

[1] Kennedy J, Eberhart R C 1995 Particle swarm optimization *IEEE International Conference on Neural Networks* **4** 1942-8

[2] Eberhart R, Kennedy J 1995 A new optimizer using particle swarm theory *Sixth International Symposium on Micro Machine and Human Science*

[3] Liang Y, Yu H, Zeng P 2006 Application of PSO optimization of wireless sensor network routing protocol based on clustering *Control and Decision* **21**(4) 453-6

[4] Xue Y, Yang Z 2008 WSN based on discrete particle swarm clustering routing algorithm *Wuhan University Natural Science version* **54**(1) 99-102

[5] Tillett J, Rao R, Sahin F 2002 Cluster-head identification in ad hoc sensor networks using particle swarm optimization *Proc IEEE Int Conf Personal Wireless Communications* [S.1.]: *IEEE Press* 201-5

[6] Latiff N M A, Tsimenidis C C, Sharif B S 2007 Energy-aware Clustering for Wireless Sensor Networks Using Particle Swarm Optimization *Proc 18th IEEE Int Symposium on Personal, Indoor and Mobile Radio Communications Athens Greece IEEE Press* 1-5

[7] Wang Y, Si H, Su Y, Xu P 2013 A new clustering routing algorithm for WSN based on PSO *Advanced Materials Research* **850–851**(2014) 689-92

[8] Yan X, Cheng G 2012 Balance energy consumption routing algorithm in WSN based on improved particle swarm optimization Computer Engineering and Design 33(10) 71-5

## Authors

**Minsheng Tan, China**

**Current position, grades**: professor, master tutor of University of South China, China.
**University study**: Master degree in control engineering, Hunan University, Hunan Province, China, 2005.
**Research activities**: network and information security, mobile networks and sensor networks.
**Professional Activities and Memberships**: Vice President of Computer Users Association of Hunan Province, in China, Vice President of Committee of Institute of China Hunan province college education in Computer education profession, Senior member of China Computer Federation.

**Huan zhou, China**

**Current position, grades**: master of University of South China.
**University study**: Master degree in Computer Science and Technology, University of South Hunan Province, China, 2012.
**Research activities**: trusted network.
**Professional Activities and Memberships**: member of China Computer Federation.

**Yangwei Li, China**

**Current position, grades**: master of University of South China.
**University study**: Master degree in Computer Application Technology, University of South China, Hunan province, China, 2010 the PLA.
**Research activities**: wireless sensor networks.
**Professional Activities and Memberships**: member of China Computer Federation.

**Jianxue Liu, China**

**Current position, grades**: master University of South China.
**University study**: Master degree in Computer Science and Technology, University of South Hunan Province, China, 2013.
**Research activities**: wireless sensor networks.
**Professional Activities and Memberships**: member of China Computer Federation.