International Journal of Multimedia and Ubiquitous Engineering
Vol.10, No.12 (2015), pp.297-306
http://dx.doi.org/10.14257/ijmue.2015.10.12.30

Cluster Head Selection Optimization of IOT Medical Data Transmission Ant Colony Algorithm

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Abstract

According to the standard ant colony algorithm in Internet of things (IOT) medical data transmission path selection, there are the problems of searching time is not long, easy to fall into partial optimization. This paper puts forward a kind of IOT medical data transmission model based on quantum pheromone updating and cluster heads choose optimization ant colony algorithm. First of all, using quantum bit probability amplitude encodes information of each path element, using quantum revolving doors and the route of the ants to update pheromone, then the ant search behavior is concentrated near the optimal solution, and the way of searching and restriction mechanism of avoiding precocious pheromone are combined, and finally optimizing the cluster heads of IOT medical data transmission model with the improved algorithm. The simulation experiments show that, through the pheromone update optimization of standard ant colony algorithm, and after the cluster heads optimization of IOT medical data transmission model, improved ant colony algorithm is more robust compared with the standard algorithm.

Keywords: *Quantum information; IOT medical treatment; Data transmission; Ant colony location; Cluster heads optimization*

1. Introduction

The concept of telemedicine which began in 1988, in a broad sense, telemedicine refers to using remote communication technology, holographic imaging technology, new electronic technology and computer multimedia technology to give full play to the advantages of large medical center, medical technology and equipment for medical and health conditions of poor and special environment to provide long distance medical information and services [1].With the rapid development of electronic and communication technology, people put forward the concept of Internet of things (IOT) and provides technical support for the realization of the remote medical treatment. IOT applications in telemedicine mainly include remote consultation and mobile medical two aspects, with the increasingly mature of IOT technology, it is bound to play a huge role in promoting the progress of the whole medical system [2].

After a period of remote medical monitoring network industry development, research level had a certain and development. Intelligent health monitoring network system developed by Computer Integrated Manufacturing (CIM) can continuously acquire and analysis human physiological parameters under the motion, and then through the phone to transfer data to a remote database, realize the 24 hours monitoring for human body health [3].The ZigBee remote wireless medical network researched and developed by Datang telecom is integrated with a number of innovative technology, and it is also integrated with the application software of health and some humanized function, it can make patients

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ISSN: 1975-0080 IJMUE

easily enjoy the expert diagnostic services. Remote family health management monitoring network based on Bluetooth developed by Beijing life online provides patients with management medical service of slow disease that occupy the home [4]. Multi-parameter monitoring network system developed by Tsinghua university, Shenzhen University and other colleges and universities has been used in hospitals, Southeast university state key laboratory developed intelligent health monitoring network system based on the technology of IOT has obtained the good effect and the general recognition of the hospital [5]. The wearable wireless all physiological parameters medical monitoring network system developed by Wuxi Chinese academy of sciences sensing network information technology center will create a new future of remote medical treatment and mobile home health care system [6]. IBM proposed wisdom medical treatment, using technology to help the new health care reform, establish a set of intelligent remote medical monitoring system to achieve global health life [7]. Health Guide project opened by Intel is a new generation of integrated remote medical monitoring solution, it can make the patients manage their own Health online with relax and actively mentality at home, the doctor provides more medical information and the knowledge of personal care to make patients feel the best comfort [8]. ADI company in the United States and the Massachusetts institute of technology (MIT) make comprehensive cooperation to research and development a new generation of home health care technology, in order to make the patient have real-time inspection of physiological characteristics in the home, and it also can lower health care costs associated [9]. Cisco lead medical model innovation, it puts forward the concept of cooperative medical treatment to build a digital medical information platform which is safe, reliable, mobile, wireless, bearing life information, the patients can enjoy the remote expert diagnosis and seamless, intelligent medical services, it can eventually achieve global medical treatment [10]. Japan is a country with advanced medical technology and rapid development economic, it grasps the global high-end technology of health care products, such as the Hokkaido university institute of electronic developed remote monitoring system which can support for multiple wireless communication modes successfully, and it can be a long-term monitoring for ECG, blood pressure and other physiological changes.

In view of the problems that standard ant colony algorithm exists in the IOT medical data transmission path selection, this paper proposes a kind of IOT medical data transmission model based on quantum pheromone updating and cluster heads choose optimization ant colony algorithm, and experimental simulation is done on it to verify the validity of the model.

2. The IOT Data Transmission Model Based on Ant Colony Algorithm

Ant colony algorithm is applied to IOT data transmission problem, simply described as follows: given n data nodes, there is a data packet from a node after the one and only one to send data back to the original node, it is asked to find a shortest circuit path. The objective function of the problem is:

$$\min D = \sum_{t=1}^{n-1} d(i, i+1) + d(n, 1) \tag{1}$$

Among them, n represents n data nodes to traverse, $d(i, i+1)$ represents the distance from node i to node $i+1$, $d(n,1)$ represents the distance from n th data node back to starting data node.

If $b_i(t)$ is the number of ants at node i at t time, then $m = \sum_{i=1}^{n} b_i(t)$; $\tau_{ij}(t)$ is the pheromone concentration at path $< i, j >$ at t time, $\Gamma = \{\tau_{ij}(t) \mid v_i, v_j \in V\}$ is the collection of residual pheromone concentration on brim e_{ij} of two nodes in set V at t time. In every path, pheromone concentration is equal at the initial time, if $\tau_{ij}(0) = const$, the optimal routing based on ant colony algorithm is to find the node in digraph $G = (V, E, \Gamma)$, and obtain the minimum cost weight value to realize.

Ant $k (k = 1, 2, ..., m)$ in the process of movement, according to various path pheromone concentration determines the transfer direction. Here using taboo table $tabu_k (k = 1, 2, ..., m)$ to record the current node of Ant k, the path set do the dynamic adjustment with the evolution process of $tabu_k$ .In the process of path selection, ants calculate the state transition probability according to various paths' pheromone concentration and heuristic information of the path. If $p_{ij}^k(t)$ represents in the state transition probability that ant k moves from node i to node j at t time.

$$p_{ij}^k(t) = \begin{cases} \dfrac{[\tau_{ij}(t)]^\alpha \cdot [\eta_{ik}(t)]^\beta}{\sum_{s \in allowed_k} [\tau_{is}(t)]^\alpha \cdot [\eta_{is}(t)]^\beta}, j \notin tabu_k \\ 0, else \end{cases} \tag{2}$$

In the equation: $allowed_k = \{V - tabu_k\}$ is the next step allows ant k to select a node; α is information heuristic factor, it represents the relative importance of the trajectory; β is expect heuristic factor, it represents the relative importance of visibility; $\eta_{ij}(t)$ is heuristic function, and its expression is as follows

$$\eta_{ij}(t) = \frac{1}{d_{ij}} \tag{3}$$

In the equation: d_{ij} ——the path $< i, j >$ distance between two nodes i 、 j . To the ant k , d_{ij} is smaller, $\eta_{ij}(t)$ is higher, the $p_{ij}^k(t)$ is higher. Obviously, the heuristic function represents the expectation degree of the ants moving from node i to node j .

In order to avoiding excessive residual pheromone caused residual information submerge inspired information, using $\tau_{ij}(t)$ to represent pheromone concentration on path $< i, j >$ at t time, in the moment of $t+1$ the pheromone concentration in this path is

$$\tau_{ij}(t+1) = (1-\rho) \cdot \tau_{ij}(t) + \Delta\tau_{ij}(t) \tag{4}$$

$$\Delta\tau_{ij}(t) = \sum_{k=1}^{m} \Delta\tau_{ij}^k(t) \tag{5}$$

In the equation: ρ ——pheromone polatility, $\rho \in [0,1)$, then $1-\rho$ represents pheromone concentration residual factor, it represents the relative important degree of residual pheromone. $\Delta\tau_{ij}(t)$ is the pheromone concentration increment on path $< i, j >$ between moment t to $t+1$, at initial moment $\Delta\tau_{ij}(0) = 0$, $\Delta\tau_{ij}^k(t)$ is the pheromone concentration increment of k th ant on path $< i, j >$ between moment t to $t+1$.

But the IOT data transmission model based on ant colony algorithm has the advantages of mechanism of using distributed parallel computing, strong robustness, but the search time is long, and it is easy to fall into local optimum for its most prominent shortcomings.

3. Data Transmission Model of Cluster Head Selection Optimization Ant Colony Algorithm

3.1. Pheromone Update Based on Quantum Coding

Classical computing uses 0 and 1 to represent information, called a bit. In quantum information theory, information is the basic storage unit of quantum bits, or qubits. Quantum bit is a binary system, it has two polarization state correspond to the classical information of 0 s and 1 s of binary storage unit state. Different from classical bits, a quantum bit in addition to outside the 0 and 1 states, it also can be in their superposition.

We can use probability amplitude $\begin{bmatrix} \alpha \\ \beta \end{bmatrix}$ to represent a qubit, the probability of the individual with n qubits can be expressed as follows:

$$\begin{bmatrix} \alpha_1 & |\alpha_2| & \dots & \alpha_n \\ \beta_1 & |\beta_2| & \dots & \beta_n \end{bmatrix} \tag{6}$$

Among them, α_i 、 β_i satisfies $|\alpha_i|^2 + |\beta_i|^2 = 1$, any quantum superposition can be expressed with the quantum individual.

In the improved algorithm, using quantum bits to represent each path pheromone, the quantum information coding of k th ant in the path can be represented as:

$$Q_{\tau_k} = \begin{pmatrix} \begin{pmatrix} \alpha_{11} \\ \beta_{11} \end{pmatrix} & \begin{pmatrix} \alpha_{12} \\ \beta_{12} \end{pmatrix} & \dots & \begin{pmatrix} \alpha_{1n} \\ \beta_{1n} \end{pmatrix} \\ \begin{pmatrix} \alpha_{21} \\ \beta_{21} \end{pmatrix} & \begin{pmatrix} \alpha_{22} \\ \beta_{22} \end{pmatrix} & \dots & \begin{pmatrix} \alpha_{2n} \\ \beta_{2n} \end{pmatrix} \\ \dots & \dots & \begin{pmatrix} \alpha_{ij} \\ \beta_{ij} \end{pmatrix} & \dots \\ \begin{pmatrix} \alpha_{n1} \\ \beta_{n1} \end{pmatrix} & \begin{pmatrix} \alpha_{n2} \\ \beta_{n2} \end{pmatrix} & \dots & \begin{pmatrix} \alpha_{mn} \\ \beta_{mn} \end{pmatrix} \end{pmatrix} \tag{7}$$

Among them, the total number of data transmission nodes is n , $\begin{pmatrix} \alpha_{ij} \\ \beta_{ij} \end{pmatrix}$ is the probability of pheromone in the path between data transmission node i to j , when $i \neq j$, $|\alpha_{ij}|^2 + |\beta_{ij}|^2 = 1$ ；For data transmission nodes i and j , when the ant moves through the path from i to j , and it will make the path pheromone probability amplitude β_{ij} increasing, pheromones can be strengthen; On the contrary, the pheromone on the path will be reduced.

When all the ants have built their own path, the information on the side will be updated accordingly. First of all, the pheromones on the each side are going to reduce the size of a constant factor, and then pheromone of the paths which the ant go through will increase. The pheromone evaporation formula is as follows

$$\tau_{ij} = (1-\rho)\tau_{ij}, \forall (i, j) \in A \tag{8}$$

Among them, ρ is the pheromone evaporation rate, the effect of parameters is to avoid infinite accumulation of pheromones. When the step of pheromone volatilization is completed, all the ants will release their pheromone in respective path:

$$\tau_{ij} = \tau_{ij} + \sum_{k=1}^{m} \Delta \tau_{ij}^{k}, \forall (i, j) \in A \tag{9}$$

Among them $\Delta\tau_{ij}^{k}$ is the amount of pheromone released by the k th ant from path i to j. $\Delta\tau_{ij}^{k}$ is defined as

$$\Delta\tau_{ij}^{k} = \left(|\beta_{ij}^{k}|^{2}\right)^{\gamma}\left(\frac{1}{C^{k}}\right) \tag{10}$$

β_{ij}^{k} represents the quantum pheromone concentration of the k th ant in the path from i to j, $|\alpha_{ij}^{k}|^{2} + |\beta_{ij}^{k}|^{2} = 1$; C^{k} is the length of path T^{k} built by the k th ant, it is the sum of all the length of the edge in T^{k}; γ is quantum information stimulating factor, it represents the relative importance of the quantum state probability amplitude from path i to j.

If there are m ants, $n \times n$ matrix R is a solution path of n IOT medical data transmission, there is only one value of an element is 1 in each row and each column of matrix R, the rest is 0. When $R[i, j] = 1$, it represents there is one edge from data transmission node i to j, when i is equal with j, $R[i, j] = 0$. Algorithm using the path found by the k th ant recorded by matrix, recording the optimal solution in the process of operation, using quantum revolving door to update quantum probability amplitude of ants in each path, the adjustment way of the quantum revolving door is :

$$\begin{pmatrix} \alpha_{ij}^{t+1} \\ \beta_{ij}^{t+1} \end{pmatrix} = \begin{pmatrix} \cos(\theta) & -\sin(\theta) \\ \sin(\theta) & \cos(\theta) \end{pmatrix}\begin{pmatrix} \alpha_{ij}^{t} \\ \beta_{ij}^{t} \end{pmatrix} \tag{11}$$

In the equation, $i, j = 1, 2, 3, ..., m$, $\left(\alpha_{ij}^{t}, \beta_{ij}^{t}\right)^{T}$ is the probability of pheromone in the t th iteration at the path between data transmission node i to j, 0 represents the rotation angle of path from i to j, it is used to control the rate of convergence of the algorithm.

3.2. Data Nodes Distribution Optimization of Ant Colony Algorithm

Then the ant search behavior is concentrated near the optimal solution, and this way of searching and pheromone restriction mechanism of avoiding precocious are combined, thus improving the ants' ability to distribute the data to the data transfer node, improving the performance of the basic ant clustering algorithm fundamentally.

The specific steps of the improved ant colony algorithm are as follows:

(1) If there is r ants, initialize the key parameter of ant colony algorithm α, β, ρ, P_{best}, $NC_{\max}$, and initialize the visibility function

$$\mu_{ij} = \begin{cases} \dfrac{1}{d_{ij}}, d_{ij} \neq 0 \\ 1 \quad , d_{ij} = 0 \end{cases} \tag{12}$$

Among them, d_{ij} represents the distance from distribution site i to distribution center j, μ_{ij} represents the expectation degree of gather for a class from distribution site i to distribution center j.

(2) Cycles number $NC \leftarrow NC + 1$.

(3) Set the ants' taboo table $tabu_{k}(t)$, it is used to record the data node which has been picked up by ant k at t moment.

(4) Make the candidate data center as the nest center $z_{j}(j = 1, 2, ..., m)$.

The ants make the nest center as the center, while allowing the data nodes randomly select a data node, put the data node at the center of the nest z_{j} with probability $p_{ij}^{k}(t)$, and put the data node in a taboo table, if taboo table is full, then turn to (6), otherwise repeat step (5).The probability $p_{ij}^{k}(t)$ is

$$p_{ij}^{k}(t) = \begin{cases} \dfrac{\tau_{ij}^{\alpha}(t)\mu_{ij}^{\beta}(t)}{\sum_{s \notin tabu_k} \tau_{is}^{\alpha}(t)\mu_{is}^{\beta}(t)}, & j \notin tabu_k \\ 0, & j \in tabu_k \end{cases} \tag{13}$$

(6) Record the system total cost E_k of data node transmission model received by k th ant distribution, among them

$$E_k = \sum_{j=1}^{m} f_j + \sum_{j=1}^{m} g_j + \sum_{j=1}^{m} l_j \tag{14}$$

Ant completes a cycle and document classification results.

(7) If all the ants have completed a cycle, the system total cost of data node transmission model distributed to all ants in the circulation are compared, and find out the ant which finds the lowest total cost (set as ant s), only to make the ant update pheromone, Suppose pheromone increment is $\Delta\tau_{ij}^{s}$

$$\Delta\tau_{ij}^{s} = \begin{cases} \dfrac{1}{E_s}, if\ i \to j \\ 0\quad, else \end{cases} \tag{15}$$

(8) Update the pheromone

$$\tau_{ij}(t+1) = (1-\rho)\tau_{ij}(t) + \Delta\tau_{ij}^{s} \tag{16}$$

And record the optimal solution.

(9)According to the formula

$$\tau_{\max} = \frac{1}{\rho E_{gb}} \tag{17}$$

And

$$\tau_{\max} = \frac{\tau_{\max}\left(1 - \sqrt[m_1]{P_{best}}\right)}{(avg-1)\sqrt[m_1]{P_{best}}} \tag{18}$$

Calculate the upper limit $\tau_{\max}$ and lower limit $\tau_{\min}$, among them E_{gb} is the optimal cost so far to find, m_1 is distribution site number, then impose restrictions on pheromones, make its meet $\tau_{\min} \le \tau_{ij}(t) \le \tau_{\max}$.

(10)If it satisfies to the end conditions of algorithm, namely $NC \ge NC_{\max}$, then the end of the cycle and output program calculated results, otherwise empty taboo table and turn to step (2).

3.3. Cluster Heads Optimization Based on Improved Ant Colony Algorithm

The improved algorithm is adopted to IOT medical data transmission model of cluster head selection optimization, considering the node energy levels, relative position between the node and the balance of the whole network energy. First node clusters, then, cluster heads send the data to the node by more jumping. The probability P_{CHi} of calculating node N_i to be a cluster head is as follows:

$$P_{CHi} = [1/(d_i+1)]^{\alpha} \cdot E_i^{\beta} \tag{19}$$

On the type, E_i represents the current energy level of the node, α and β represent the node's weight value of distance to the center of the cluster geometry and energy. Ant i on the cluster head r selects cluster head s as the next-hop node based on the type:

If $\rho < \rho_0$,

$$\rho_i(r,s) = \begin{cases} 1, \max(PH_i(r,s)), s \in Nb_i(r) \\ 0, else \end{cases} \tag{20}$$

Or

$$\rho_i(r,s) = \begin{cases} \dfrac{PH_i(r,s)}{\sum_{u \in Nb_i(r)} PH_i(r,u)}, s \in Nb_i(r) \\ 0, else \end{cases} \tag{21}$$

In the equation, ρ is a uniformly distributed random number, ρ_0 is a constant. $\rho_i(r,s)$ represents the probability ant i on the cluster head r selects cluster head s as the next-hop node. $PH_i(r,s)$ represents the sum of pheromone of ant i from the cluster head r to s. $Nb_i(r)$ is the neighbor nodes collection which ant i has not arrived in the cluster head r.

4. Algorithm Performance Simulation

In order to verify the performance of the improved algorithm proposed in this paper, simulation experiments is done on it, make the internet of medical data in a certain area as example, using the standard ant colony algorithm and the proposed cluster head selection optimization ant colony algorithm for data transmission path selection optimization, first of all, in the case of 10 data node, transmitting data of different size, testing its transmission speed, the results shown in the Figure below.

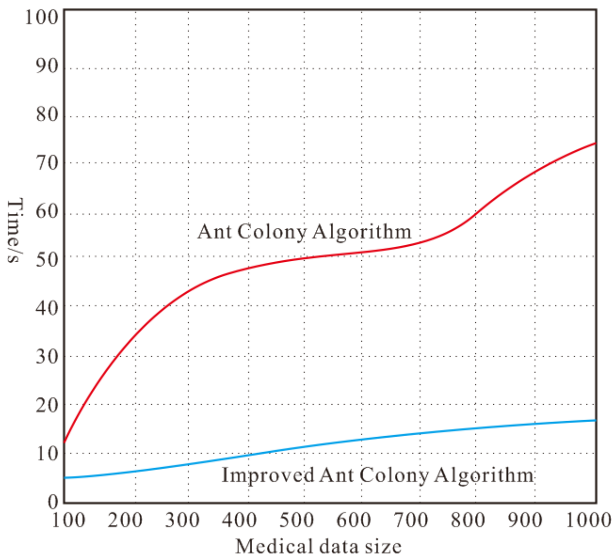

Figure 1. Transmission Time Comparison Results in Case of the Same Number of Nodes

Then in the case of different number of data nodes, transmitting the same size data, the results shown in Figure below.

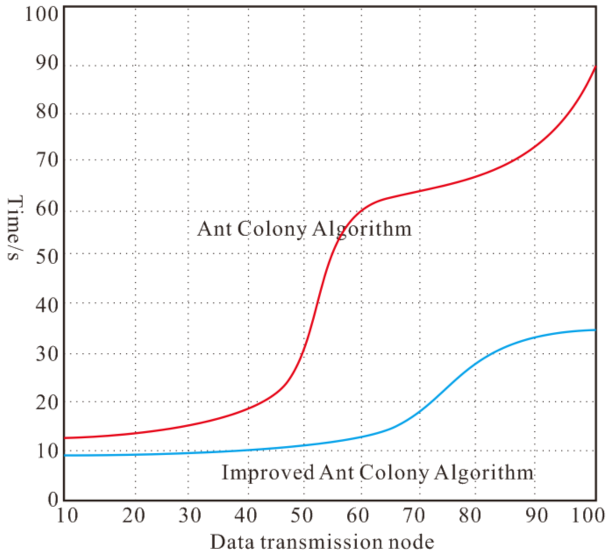

Figure 2. Compare the Results of the same Data Transmission Time Careful Case

It can be seen from the above results, through the optimization of the pheromone update to standard ant colony algorithm, and after the cluster head optimization of IOT medical data transmission model, improved ant colony algorithm compared with standard algorithm is more robust.

5. Conclusions

In recent years, with the rapid development of emerging IOT technology and the short distance wireless communication technology, remote medical monitoring network technology has become a hot research topic, it provides convenience for people to see the doctor, enhance their own health care consciousness and promote the development of hospital medical technology. In view of the standard ant colony algorithm has the problems that exist in the path selection of IOT medical data transmission, this paper proposes a kind of IOT medical data transmission model based on quantum pheromone updating and cluster heads choose optimization ant colony algorithm, the experimental simulation results show that the improved ant colony algorithm compared with the standard algorithm is more robust.

Acknowledgment

This work was supported by:

1. Youth Foundation of the Education Department of Hebei Province（QN2014182）
2. Major project of Hebei North University (ZD201301)
3. Hebei Province Population Health Information Engineering Technology Research Center
4 Youth Foundation of the Education Department of Hebei Province（QN2015225）
5. Youth Foundation of Natural Science of Hebei North University (Q2014008)

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