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Bluetooth Optimization Design of Intelligent Medical Kit Based On Ant Colony Algorithm and TABU Search Algorithm

LIU Gai, LIU Wei-ting, WEI Hai-feng，XU Yuan，RUAN Shi-hao

（School of Electrical and Information, Jiangsu University of Science and Technology, Zhenjiang 212003）

Abstract: Aiming at the problems of slow convergence and easy falling into local optimization for Bluetooth transmission optimization algorithms in existing Bluetooth devices. This paper presents a design method of antenna optimization based on ant colony optimization algorithm and tabu search algorithm, there is better Bluetooth transmission efficiency through regulating the π circuit, using the combination of ant colony algorithm and tabu search algorithm, which not only makes the system has good robustness and distribution, but also solving the problem of local optimum easily of the ant colony algorithm. Testing through the Bluetooth MT8852B comprehensive test instrument, and chosing three different frequencies which is low frequency, intermediate frequency and high frequency. The system with the ant colony algorithm and tabu search algorithm, improves the problems of convergence speed and easy to fall into local optimum. The experiment shows that this design can improve the transmission efficiency of bluetooth.

Key words: Bluetooth device； ant colony algorithm； tabu search algorithm

0 Introduction

Now the old man often forgot to take medicine, using the smart box can effectively solve this problem, the Bluetooth transmission quality has great influence on the smart devices, Bluetooth smart devices exist signal transmission error or low transmission efficiency. Therefore, it is necessary to improve the transmission quality of intelligent devices, and all Bluetooth devices need to strengthen Bluetooth signals through antennas.

Literature [1] proposed to enhance Bluetooth transmission capability by changing the external circuit, adjusting type circuit resistance and capacitance between Bluetooth chip and antenna can realize the value of Bluetooth transmission efficiency optimization; Literature [2] proposed to put the ant colony algorithm forward into the software, it has a very good effect in solving combinatorial optimization problems, but to easy to fall into local optimum; Literature [3] proposed to add genetic algorithm in software, the genetic algorithm has a strong global search capability, but it is to easy to result in serious redundancy and low efficiency, and the feedback information has not been fully utilized; Literature [4] proposed to add tabu search algorithm in the software, by preserving the search path, and setting some of the path, which is forbidden to continue the search (not absolute prohibition) or continued to search. The algorithm is guaranteed not to fall into local optimum, while ensuring the optimal path not to lost; Literature [5] presents a logical link control by using backoff N frame retransmission algorithm and the adaptive layer retransmission algorithm, this algorithm not only has low efficiency, but also need to buffer large space; the efficiency of SR algorithm proposed in the Literature [6] comes close to the ideal retransmission algorithm, but the transmission and reception has logical problems and at the cost of efficiency of buffer space.

In this paper, using a combination of ant colony algorithm and tabu search algorithm in logical link control and adaptation layer, not only makes the design has good robustness and distribution, but also solves the problem that the ant colony algorithm is prone to local optimal; secondly, adjusting type circuit resistance and capacitance between Bluetooth chip and antenna can realize the value of Bluetooth transmission efficiency optimization; Experimental results show that the proposed algorithm combined the ant colony optimization algorithm and the tabu search algorithm improved the Bluetooth transmission efficiency of the intelligent medical kit.

1 Bluetooth technology introduction

This design is for improving the Bluetooth transmission efficiency of the intelligent medicine box, thus realizing the better use of the intelligent medicine box. Bluetooth technology has been the focus of attention, and also the focus of attention of researchers. However, there are still some issues that need to be researched in Bluetooth data transmission. In the baseband layer, different features can be displayed during the transmission because of the different grouping types of bluetooth. It is valuable to study packet formats that best fit the current channel quality of these packet types. Therefore, a number of different packet type selection algorithms are proposed in many literatures. In the logical link control and adaptation layer, the retransmission algorithm is the factor that affects the transmission efficiency. Since the retransmission algorithm specified in the protocol is a n frame retransmission algorithm, the algorithm is not only inefficient, but also requires large buffer space, so it is not suitable for applications. In order to improve the performance of Bluetooth data transmission, a variety of algorithms are proposed for these two levels. But there are still some problems.

When the packet type is selected in the baseband layer, the selection method has the problem of poor performance, especially when the signal-to-noise ratio is low, which will affect the overall efficiency of the system. In the logical link control and adaptation layer, the current retransmission algorithm is efficient, but the conditions are more stringent. Some systems can not even be implemented, which greatly reduces the application rate. Aiming at the retransmission of logical link control and adaptation layer. The SR+ST algorithm, which is very close to the efficiency of the ideal retransmission algorithm, is hard to transmit and receive, and the efficiency is at the cost of buffer space. Due to the adoption of a high performance selection mechanism, the baseband layer can not work efficiently and different retransmission algorithms are used under different conditions.

2 Algorithm description

2.1 Ant colony algorithm

When the Bluetooth intelligent kits communicating with other equipments, as the reason of software or other interference signal, the efficiency of Bluetooth data transmission will decrease, thus adding ant colony optimization algorithm (ACO) to improve the efficiency of Bluetooth transmission is very necessary. The ant colony optimization algorithm is described as follows:

The ants in the course of action, will left a matter of substance that can transmit information in the path, the substance called pheromone, ants can find the hormone during exercise, after walking on the path of hormone concentration, so the ant colony collective behavior consists of a large number of ants showed a positive feedback phenomenon: the more the number of ants through a path, the greater probability that the behind ants to choose the path. Algorithm is as follows:

$$p_{ij}^{k} = \frac{\tau_{ij}^{\alpha}\eta_{ij}^{\beta}}{\sum \tau_{ij}^{\alpha}\eta_{ij}^{\beta}} \qquad (2.1)$$

$$\tau_{ij}(n+1) = \rho \times \tau_{ij}(n) + \sum_{k=1}^{m} \Delta\tau_{ij}^{k} \qquad (2.2)$$

$$\Delta\tau_{ij}^{k} = \frac{Q}{\sum L_k} \qquad (2.3)$$

m is the number of ants; **n** is the number of iteration; **i** is the ant location; **j** is the position that ant can reach; η is the heuristic information, the visibility of the path from **i** to **j**; **τ** is the pheromone intensity from i to j; $\Delta\tau_{ij}^{k}$ is the amount of pheromone of ant **K** from **i** to **j**; ρ is the evaporation coefficient of the number of pheromones on the path ; **Q** is quality factor of pheromone; L_k is the transition probability from position **i** to position **j** mobile of ant **K**.

2.2 Tabu search algorithm

The most important idea of the taboo search algorithm is to save the search path, and to set some of the path which is forbad to continue search (not absolute prohibition) or continue to search. It ensures that the algorithm is not trapped in the local optimum, and also ensures that the optimal path is not lost. Tabu search algorithms are described below:

First of all, we need to give a current solution, an empty tabu list and a neighborhood search method. Secondly, the candidate solution is determined by searching the neighborhood of the current solution in the neighborhood. If the optimal candidate solution in the current neighborhood is the optimal solution, then the object is added to the tabu search table, and the number of each object in the tabu list is reduced by 1, and the current optimal solution is replaced. If the candidate solution does not have the optimal solution, the optimal candidate solution is added to the tabu list, and the number of each object in the tabu list is reduced by 1, and the search process is repeated until the condition is satisfied.

3 Tabu search ant colony algorithm

3.1 The combination of the Ant colony algorithm and tabu search algorithm

This paper is combined with the method of ant colony algorithm and tabu search algorithm, we use tabu search algorithm by using tabu search table to prevent the search into a local optimal idea in ant colony algorithm, adding a tabu search algorithm for optimization of table.

In this paper, tabu search algorithm is used to improve the ant colony algorithm. Mainly in the following two aspects: first, set up a tabu search table, which is used to store each round of search to the optimal solution. The tabu list here differs from other papers in the tabu list, which is used to store ant nodes that have passed the tabu list of other papers, and this tabu search is the best storage solution for each round search. The tabu table is used to save the search results at the same time, so as to prevent the loss of the optimal solution. Second, the pheromone of each round of the optimal solution is updated separately.

3.2 Ant colony algorithm and tabu search algorithm

Bluetooth data packets are used to transfer the best process between Bluetooth devices, and the process of implementation is described in detail. Suppose you have **m** packets, and **n** Bluetooth devices. The initial definition information concentration is $\tau_{ij}(0)$ = C (C is constant). Packets find a path in **n** nodes, so that all nodes are visited in the shortest path. You need to keep two collections for each packet, one collection named **before** store all nodes that the packet i visited , and another collection named **after** store all nodes that the packet j not visited. Set up a tabu list of length **K** at the same time. **K** sets the number of rounds for packet searches. This makes it convenient to compare the results of each round.

First, determine the number of Bluetooth devices and build a roadmap. Set an empty tabu search table. The **m** packets are randomly placed into **n** nodes, and the packets are randomly selected. In the initial state, the pheromone concentration on each path is consistent, and the packet randomly selects a path. Since the concentration of information on each path in the initial state is the same, the first selection is not affected by the concentration of information. Each time the next node is selected, it depends on whether the node is in the **before** table, that is, the table of nodes has been passed, if so and put the node in the **before** table. When all the nodes are searched in the **before** table, after the first time in the search for information is completed, update the concentration of the length of the path. Path selection is shown in equation 3.1:

$$P_{ij}^{k}(t)=\begin{cases}\dfrac{\left[\tau_{ij}(t)\right]^{\alpha}\left[\eta_{ij}(t)\right]^{\beta}}{\sum\limits_{s\subset after_k}\left[\tau_{is}(t)\right]^{\alpha}\left[\eta_{is}(t)\right]^{\beta}}, & \text{if } j\in after_k\\ 0, & \text{else}\end{cases}\qquad(3.1)$$

$P_{ij}^{k}(t)$ represents the probability that packet **k** will shift from node **i** to node **j**. $\tau_{ij}(t)$ represents the pheromone strength on the path **i** to **j**, $\eta_{ij}(t)$ indicating the importance of the information on the path **i**

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to **j**. α, β is a parameter of two fixed values.

After that, update the pheromone. The concentration information is updated on a path search in all packets to search for updates, m packets in a search can search m paths. Updates are shown in formulas 3.2 and 3.3. □□

$$\tau_{ij}(t) = \rho * \tau_{ij}(t-1) + \Delta\tau_{ij}(t-1) \quad (3.2)$$

$$\Delta\tau_{ij}(t) = \begin{cases} \frac{\rho}{m} & \text{, if the path is the best path} \\ 0 & \text{, else} \end{cases}$$

(3.3)

Among them, ρ is the coefficient of retention of pheromones. In each search, updates are made for each search path, but ways to update are made differently. For the common path, only some of the volatile concentration of information on the path, but to find the optimal path in a search for pheromone concentration increased properly, this can be optimal in the round to make full use of the data packet to search the solution. In this part of the information concentration update, this article is called a round after searching a certain number of times. After each round, the best path is stored in the tabu list. For each round of frequency control, the algorithm is mainly to fast convergence. Ant colony algorithm runs a certain number of times, the algorithm will fall into the local optimum. Therefore, after the end of each round of operation, the path with the highest information concentration is adjusted, that is, the optimal path is adjusted separately and the problem that the algorithm is trapped into the local optimum is solved. Update the pheromone path that will be added to the tabu table. Update as shown in equation 3.4: □

$$\tau *_{ij}(t) \begin{cases} \theta * \tau_{ij} & \text{, i and j is the path} \\ \tau_{ij} & \text{, else} \end{cases}$$

(3.4)

In the above formula, the optimal path is reduced accordingly, and the reduced coefficient is 0< θ <1. So to reduce the optimal path pheromone concentration, increase the possibility of the other path searched, to prevent the algorithm into a local optimal solution. For the length of tabu table, this paper sets the degree of tabu table as the number of wheels in the algorithm. The sample setting allows us to visually see the optimal solution for each round.□□

4 System function test and analysis

In order to test our conclusion, we use the Bluetooth tester MT8852B to test,

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select three channels from the 39 channels of Bluetooth, respectively low frequency 2402MHz, intermediate frequency 2440MHz, high frequency 2480MHz, respectively pass data through the three channel data, the results are as follows:

The antenna part kits and MT8852B directly connected, which can get the test data in MT8852B, figure 1 shows the test of LOG MAG chart, the chosen channel 1 is low frequency frequency, the chosen channel 2 is intermediate frequency, the chosen channel 3 is high frequency, in the graphics, we can see the three points are below the horizontal line, and the value is low, that means the Bluetooth transmission performance of the intelligent box is good after adding the ant colony algorithm and tabu search algorithm; Figure 2 is SMITH CHART, in the graphics, we can see all of the three points are almost in the same circle, and in a relatively close distance, that means the Bluetooth transmission performance of the intelligent box is good after adding the ant colony algorithm and tabu search algorithm; Figure 3 is SWR CHART, in the graphics, we can see the value of the three points is low, that means the Bluetooth transmission performance of the intelligent box is good after adding the ant colony algorithm and tabu search algorithm.

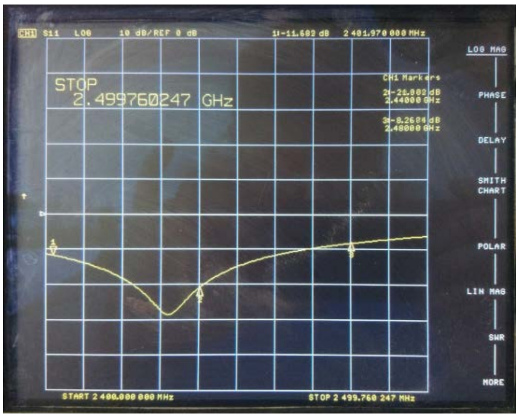

Fig.1 LOG MAG chart

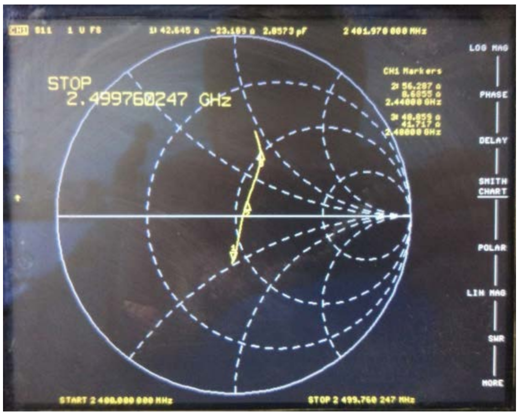

Fig.2 SMITH chart

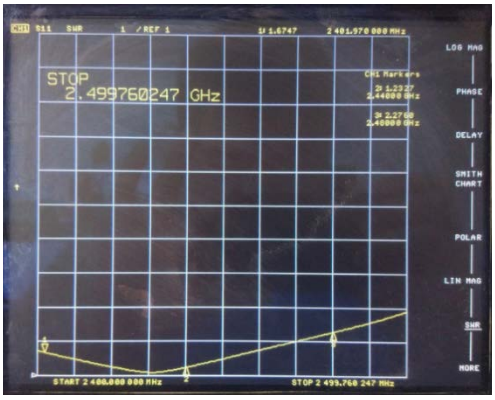

Fig.3 SWR chart

The intelligent medicine box connects with the Bluetooth tester by the way of coupling, sending datas in the three channels, the standard transmission energy of the chip 8dBm, The table 1 shows that the received energy of MT8852B is 6.67dBm-7.03dBm, the loss of energy is small; the way of transmission of Bluetooth signal is frequency hopping technology, when the transmission in a channel, if the channel transmission rate is low or the influence by environment is too big, the transmission will go directly to the next channel, a channel bandwidth is 2MHz, as shown in Table 2, through the test of three channels, we found that the frequency offset of each channel is only 20-25kHz, it will not affect the data transmission of the different channels; Testing the packet reception rate by using MT8852B algorithm, we can see from table 3, sending 1500 Bluetooth data packets, MT8852B packet received in 1270-1326, sending failure rate very low.

Table 1 Test data of different channel output energy

	low frequency	intermediate frequency	high frequency
average energy	6.67dBm	7.03dBm	6.67dBm
maximum energy	6.67dBm	7.03dBm	6.68dBm
minimum energy	6.75dBm	7.02dBm	6.67dBm
The total test package	10	10	10
Test failed package	0	0	0

Table 2 Test data for frequency offset of different channels

	low frequency	intermediate frequency	high frequency
the average frequency deviation	-20.4kHz	-23.1kHz	-25.9kHz
the maximum frequency deviation	-18.8kHz	-21.9kHz	-24.4kHz
the minimum frequency deviation	-24.7kHz	-26.9kHz	-28.3kHz
drift rate /50us	5.10kHz/50us	5.01kHz/50us	4.96kHz/50us
maximum shift	-5kHz	-5kHz	-4kHz
minimum shift	-4kHz	-4kHz	-2kHz
the total test package	10	10	10
test failed package	0	0	0

Table 3 Test data for different channel frequency offset data sent and received by different channels

	low frequency	intermediate frequency	high frequency
Contract number	1500	1500	1500
Receive packets	1270	1271	1326
Transmission failure rate	15.33%	15.27%	11.60%

5 Conclusion

This paper presents a design method of antenna optimization based on ant colony optimization algorithm and tabu search algorithm, there is better Bluetooth transmission efficiency through regulating the π circuit, using the combination of ant colony algorithm and tabu search algorithm, which not only makes the system has good robustness and distribution, but also solving the problem of local optimum easily of the ant colony algorithm. Testing through the Bluetooth MT8852B comprehensive test instrument, and chosing three different frequencies which is low frequency, intermediate frequency and high frequency. The system with the ant colony algorithm and tabu search algorithm, improves the problems of convergence speed and easy to fall into local optimum. The experiment shows that this design can improve the transmission efficiency of bluetooth.

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