Channel Allocation Scheme for Wireless Sensor Networks Based on Graphical Topology Information

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Abstract. Wireless sensor network (WSN) is a distributed sensor network. The main research direction of wireless sensor network is the distribution method of its channel. With the development of information technology, the contradiction that between scarce wireless resources and high-density AP points will adversely affect people's daily life. In this paper, we design a heuristic algorithm based on the channel assignment method by comparing the similarity of the network graphic topology. By calculating the pre-allocation scheme, the optimal throughput of the new topology is compared with the optimal throughput of the genetic algorithm to verify the superiority in the new algorithm. The network model is constructed by three graphical methods: scatter plot, density map and thermal graph. Finally determine the heat map-based channel allocation algorithm as the optimal solution.

1. Introduction
When we face the problem of channel allocation in wireless sensor networks, the most direct method is to assign directly to the greedy sub-algorithm. But the biggest disadvantage of the greedy algorithm is that it is easy to fall into the local optimal solution and cannot obtain the optimal solution, which made the network throughput low and cannot meet the high quality requirement of real-time communication. In order to optimize the channel allocation of wireless sensor networks and reduce the energy consumption of data transmission, Hu Jie proposed an improved genetic simulated annealing algorithm based on path optimization algorithm[1]. This algorithm optimized the real-time performance of wireless sensor networks, but the demand for high throughput in wireless sensing networks has not been satisfied yet.

Based on the heuristic algorithm, this paper uses the uniform distribution method to obtain the optimal allocation method. First, use heuristic algorithm to calculate the information entropy of each topology information. Topological information with the largest information entropy as the highest priority element for channel allocation, after the heuristic algorithm completes the channel assignment, optimizing the current allocation strategy using genetic algorithms. Channel assignment strategy using genetic algorithm as the original database. Graphical topology channel allocation based on this database. Saving a lot of time and improve efficiency on the premise of approaching the best possible.

2. Channel Allocation Algorithm Design Flow
2.1. A Similarity Recommendation Algorithm Based on Scatter Plot
Similarity is usually used to describe the degree of similarity between two objects. There are many ways to calculate similarity, one of the simplest model is like two points in two-dimensional space, to judge the similarity between the two groups of points. The similarity between the points on the two-dimensional plane is calculated by calculating the Euclidean distance between the two groups of points.
The distance difference determines the similarity. The similarity algorithm of Euclidean distance will be affected by subjective factors. For example, when the distance difference between the two groups is 5, if A considers 5 as a relatively small number, and B considers 5 as a very large number. In addition to the simplest similarity application model, common similarity comparison calculations include Pearson correlation coefficient similarity comparison, cosine similarity comparison, and mutual information similarity comparison.

The similarity algorithm of Euclidean distance mentioned above is not applicable to the actual situation, because of the influence of subjective factors. Compared with the Euclidean distance similarity algorithm, the cosine similarity focuses more on the direction of the vector, which leads to another problem, that is, the similarity in the direction of the two vectors is high, and the length of the vector is very large and small angles can also lead to extreme differences, which is a limitation of the cosine similarity algorithm.

Then is the mutual information quantity similarity algorithm. This method is commonly used in image processing and it is a similar algorithm based on pixel computing mutual information. Because the network model in this article is a graphical topological graph, that is, an image, it is possible to consider using the method of mutual information to calculate the similarity. By consulting the data, the mutual information similarity algorithm can calculate the amount of mutual information about one image and multiple different images, and the obtained degree of similarity is relatively large. Therefore, this paper chooses the mutual information similarity algorithm to calculate the similarity with the graphical topology.

\[ d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + \ldots + (y_n - y_{n2})^2} \]  
\[ \cos(\theta) = \frac{\sum_{i=1}^{n} (x_i \times y_i)}{\sqrt{\sum_{i=1}^{n} (x_i)^2} \times \sqrt{\sum_{i=1}^{n} (y_i)^2}} \]  
\[ MI(U,V) = \sum_{i=1}^{g} \sum_{j=1}^{c} P(i, j) \log \frac{P(i, j)}{P(i)P(j)} \]  

```python
for imgnum in range(0, imgMax):
    img2 = imread('train/sample%d/%d.JPG'%(imgnum, imgnum)) # Read Database Sample User Distribution Map
    img2 = np.reshape(img2, -1)
    mutual_infor = mr.mutual_info_score(img1, img2) # Calculate the similarity of the two samples
    mutual[imgnum] = mutual_infor
    _position = np.argmax(mutual)
    Throught = np.loadtxt('train/sample%d/strategynum.txt'%(position), encoding='utf-8', delimiter=',')
    ThroughtSum = np.sum(Throught[:,2]) * 100
```

Figure.1 Code Implementation of Similarity Contrast Algorithm

The formula used above is as follows:
\[
Binwidth = \frac{\max(x) - \min(x)}{n}
\]  
(4)

\[
edges = \sum_{i=0}^{n} (\min(x) + binwidth \times i)
\]  
(5)

\[
H(X) = E(I(X)) = -\sum_{i=1}^{n} p(x_i) I(x_i) = -\sum_{i=1}^{n} p(x_i) \log_e p(x_i)
\]  
(6)

\[
I(X,Y) = H(X) + H(Y) - H(XY)
\]  
(7)

The topology model mentioned above, this paper will make the topology model into a scatter plot with attribute, in which the location information, interference degree and number of interference points of each node in the network are represented in the scatter plot.

2.2. A Similarity Recommendation Algorithm Based on Thermal Graph

Since the white part of the scatter plot is the dominant color, the similarity in each scatter plot is very high. If a scatter plot is used to construct a graphical topology, the discrimination will be lower than the heat map. In this paper, in addition to displaying the location information and interference levels of all user nodes in the form of scatter plots, a heat map model of the network is also established. The heat map can reflect the number of user nodes in the current network and their perception radius through the difference in the range of the halo and color depth. As shown in Fig. 2, the similarity relation between scatter plot and thermal map can be more differentiated.

When entering the graphical topology information of the new network, the system compares the similarity with the new graphical topology information about all the graphical topology information on the current database, selects the graphical topology with the highest similarity, and obtains its allocation strategy. And calculate the total network throughput when the new graphical topology uses this strategy. The original database is composed of the optimal allocation strategy obtained by iteratively updating 1000 existing different network topologies through genetic algorithms. When there is a new network input, it will first go through the channel allocation algorithm of the graphical topology, and then re-traverse the network by genetic algorithm to obtain the optimal allocation strategy of the new network and store it in the database. In order to verify which of the graphical topology channel assignment algorithms yields the best results, experiments are performed on heat map and scatter plot respectively.

![Figure 2 Scatter plot and distribution of corresponding thermal map](image-url)
3. Results Presented

3.1. Implementing Environment
In order to test the allocation performance of the graphical topology channel allocation algorithm, this article chooses to perform experiments in matlab 2016. The network parameters to be tested are setting as follows: The network area is a rectangular space with 10 m in length and width, the number of user nodes is 100, the radius of user communication is 2 m, the total number of wireless channels is 6, the number of network topology changes is 100, and the maximum number of evolution iterations is 5000. The data is simulated by MATLAB 2016 to generate the optimal strategy. Then the topological information of the network is drawn into a scatter map by Spyder, and the similarity of the new input topology is compared. Calculate throughput and compare with heuristic algorithm allocation scheme and optimal scheme.

3.2. Analysis of Results
With the control variable method, the number of AP nodes in the network is used as an independent variable to make it increase from 0 to 100. Heuristic algorithms and genetic algorithms were used for this network to observe the differences in network throughput. The observation results show that the total throughput of the genetic algorithm network gradually increase with the number of AP nodes and is higher than the heuristic algorithm. Figure 3 below shows the network throughput of the genetic algorithm and heuristic algorithm as the number of AP points increases.

This paper compared and analyzed the difference of the distribution result of the network total throughput between the genetic algorithm and the scatter plot similarity recommendation algorithm under the general simulation method and Monte-Carlo simulation. It can be concluded that the similarity comparison algorithm of scatter plot can make the policy recommendation of the condition of approximating the optimal allocation.

Because the frequency range of network topology change cannot be predicted, we cannot distinguish the variation of network topology information completely from similarity by comparing recommendation algorithm based on scatter plot similarity. From the comparison of the distribution results between the scatter plot similarity recommendation algorithm and the thermal map similarity recommendation algorithm, the distribution result of the thermal map will be more differentiated, and the curve will have almost no straight line with the same distribution result, while the scatter plot will occasionally have the phenomenon of possible assignment to the same strategy under different topologies.

![Figure 3 Genetic Algorithm and Recommended Algorithm Allocation Strategy Throughput](image-url)
3.3. Analysis of Advantages and Disadvantages of Algorithm

From the distribution results, the total throughput of the network obtained by the genetic algorithm is slightly larger than that obtained by the recommendation algorithm, but in terms of time cost, the recommendation algorithm can give the allocation strategy quickly, and it is almost the same as the optimal strategy of the network. Therefore, it can be concluded that the recommendation algorithm can greatly approximate the most strategy in the allocation strategy, and can save a lot of time cost. Compared with the two simulation methods, the general simulation method can give the simulation results quickly, but the simulation results are serrated, and there is uncertainty.

To sum up, the time cost and distribution results can be controlled in a more efficient range by using the recommendation algorithm and Monte Carlo simulation method. Compared with the combination of genetic algorithm and Monte Carlo simulation, it can save more time cost, and it can be better than the allocation result of the strategy provided by the recommended algorithm and the conventional simulation method. The recommendation algorithm chooses the method based on the thermodynamic graph with better differentiation than the method based on the scatter plot. From the comprehensive point of view, this paper chooses the similarity comparison recommendation algorithm based on the thermal graph to provide the allocation strategy and adopt Monte-Carlo. It is more scientific to compare the results with the simulation method.

3.4. Theoretical Analysis of Algorithms

It can be seen from the above simulation results that the result of the genetic algorithm allocation network throughput is slightly better than that of the recommendation algorithm because the recommendation algorithm is recommended to the most similar strategy by comparing the similarity between the new network and the network of the database, and the network of the database is the optimal allocation strategy after thousands of iterations of the genetic algorithm. The advantage of the recommendation algorithm lies in the high real-time, while the disadvantage is that the recommendation result is not necessarily the optimal allocation result. Genetic algorithms are optimal assign results, it takes a lot of time and is less real-time than recommended algorithms. The time required for the simulation of the two algorithms is compared and found that the recommended algorithm operation speed is obviously better than the genetic algorithm, the results are shown in figure 4 below, the horizontal axis represents the number of user nodes in the network, and the vertical axis represents the time required for the two algorithms to process the new network.

![Figure 4](image-url)

**Figure 4** Comparison of Genetic Algorithms and Recommended Algorithms

Genetic algorithms take longer to process a single network. The network of 100 user nodes increasing one by one is entered into the model, and the relationship between the time of the network and the number of user nodes is obtained, and the real-time performance of the two algorithms can be
compared. After simulation comparison, it is found that the network processing 100 user nodes, the recommended algorithm takes approximately 2.7 s, the genetic algorithm takes 4.7 s, and the time consuming increases with the increase of the number of user nodes. By comparison, the real-time performance of the recommendation algorithm is slightly better than that of the genetic algorithm.

3.5. Conclusions
In distributed network topology, dynamic allocation has become a key technology for wireless sensor networks. Therefore, this paper focuses on dynamic channel allocation algorithms in distributed networks. This article compares several related algorithms of distributed networks. Learned about the advantages and disadvantages of several common channel assignment algorithms. Comprehensive analysis of different algorithms to obtain the optimal dynamic distribution algorithm for distributed networks. By collecting the topology information in the network, the graphical topologies of scatter plots and heat maps are constructed. Then, for the factors that may affect the channel allocation in the network, a channel topology algorithm based on the graphic topology of the heat map is proposed.

In this paper, a graphical topology is used to construct the network model. By comparing the allocation results of different graphical topological channel assignment algorithms, a heat map with the highest allocation quality is selected to construct a graphical topology. The process of model construction and algorithm design method are described in detail through text and simulation. In addition to the graphic topology channel assignment algorithm based on heat map, this paper also proposes a graphical topology channel assignment algorithm based on the scatter plot to compare with the former. Finally determine the heat map-based channel allocation algorithm as the optimal solution.

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