A resource allocation algorithm for communication interference

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Abstract. Aiming at the problem of interference resource allocation in communication, an interference resource allocation algorithm based on Breadth First Search (BFS) is proposed in this paper. In the jamming problem, the jammer can interfere with the target on a number of frequencies. Affected by some factors, the jamming frequency of a single jammer needs to be concentrated as much as possible. The frequency point set is divided into multiple frequency bands. The signals in the same frequency band are considered to be close to each other. The optimization problem is transformed into allocating the least jamming frequency band of jammer. The optimal interference resource allocation method of the model can be obtained by BFS. Simulation results show that the algorithm has significant index advantages over the manual selection of methods.

Keywords: Communication interference, Interference resource allocation, BFS.

1 Introduction

In communication interference, optimizing the selection of jamming strategy can save jamming resources and improve jamming efficiency. At present, most researchers[1][2] mainly establish communication interference model from the aspects of interference style, interference target and interference power, and obtain the optimal interference efficiency by optimizing interference parameters. Literature [3] uses hierarchical reinforcement learning algorithm for anti-interference decision-making. Literature [4] uses hierarchical reinforcement learning algorithm to make frequency resource allocation decision. Some scholars focus their research on specific applications, such as satellites [5]. Other studies take new optimization indexes as training objectives, such as maximum entropy [6].

In communication, frequency hopping communication is the most important anti-jamming method. This paper mainly aims at the problem of resource allocation when interfering with frequency hopping communication. In practical application, when allocating interference resources, it is required that the interference frequency points of a single jammer should be concentrated as much as possible. This paper makes an abstract modeling for this problem, and divides the frequency to be interfered into different frequency bands. The frequency in the same segment is considered to be close, and the frequency between different

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segments is considered to be far. The optimization problem can be transformed into the average allocation of the least interference frequency band for each jammer. In this paper, the BFS algorithm [7] is used to obtain the optimal solution under the model.

2 System model

In communication interference, the self-side conducts targeted interference according to the detected communication frequency. For conventional communication methods such as amplitude modulation and frequency modulation, it is very susceptible to narrowband interference. In communications, the anti-jamming method is generally used as frequency hopping.

Assuming that the communication frequency set obtained by reconnaissance intelligence is

$$F = F_1 \cup F_2 \cup \ldots \cup F_N \tag{1}$$

Where

$$\mathrm{F_i} = \{\mathrm{f_{i,1}}, \mathrm{f_{i,2}}, \ldots, \mathrm{f_{i,N_i}}\}(\mathrm{i} = 1,2, \ldots, \mathrm{N}) \tag{2}$$

Represents the frequency set of the $i(i = 1,2, \ldots, N)$ -th frequency band.

Order

$$F_{i,j} = F_i \cup F_{i+1} \cup \ldots \cup F_j \ (i \in \{1,2, \ldots, N\}; j \geq i) \tag{3}$$

It is assumed that each jammer can interfere with K frequency points at most, and the set of jamming target frequency points of the jammer is

$$J_t = \{f_{t_1}, f_{t_2}, \ldots, f_{t_K}\}(t = 1,2, \ldots, T) \tag{4}$$

Where, T represents the number of jammers.

Generally, the frequency points that can be interfered by the jammer are less than all the frequency points that need to be interfered, that is, it meets the requirements

$$TK \leq \sum_{i=1}^{N} N_i \tag{5}$$

Order

$$J_t \in F_{i_t,j_t}(t = 1,2, \ldots, T; i_t \in \{1,2, \ldots, N\}; j_t \geq i_t) \tag{6}$$

The optimization goal is to concentrate the interference frequency of each jammer as much as possible, that is

$$\delta = min \sum_{t=1}^{T}(j_t - i_t) \tag{7}$$

The above is a modeling of interference resource allocation in communication interference, under which the algorithm is required to obtain the optimal value of Equation (7).

3 Interference resource allocation algorithm

According to the optimization objective formula (7), if $j_t = i_t(t = 1,2, \ldots, T)$, the algorithm is optimal $\delta = 0$, that is to say the interference frequency of each jammer is within a band.

This algorithm uses BFS by a queue data structure Q to solve the problem. Try in turn $\delta = 0,1,\dots,(N-1)$ whether formulas (6) and (7) are satisfied. The algorithm terminates when a solution that meets the conditions is found, and the optimal solution is obtained. The algorithm flow is as follows:

Table 1. Interference resource allocation algorithm.

1. Initialize the parameters firstly.	
Step1:	set $node = [F_1, F_2, \dots, F_N]$.
Step2:	$Q.push(node)$
2. Run the algorithm body.	
Step3:	$node = Q.pop()$ and enter Step4.
Step4:	check $node$ by formulas (6) and (7). When the detection result is true, jump to Step10 and the algorithm ends, otherwise enter Step5.
Step5:	set value $i = 1$ and enter Step 6.
Step6:	if $i < len(node) - 1$, then enter Step 7, otherwise jump to Step3.
Step7:	set $node_i = [F_1, F_2, \dots, F_{i-1}, \{F_i \cup F_{i+1}\}, F_{i+2}, \dots, F_N]$ and enter Step8.
Step8:	$Q.push(node_i)$ and enter Step9.
Step9:	set $i = i + 1$ and jump to Step6.
Step10:	algorithm ends.

It can be seen from the algorithm implementation process, the algorithm in this article will loop out a $node$ from queue Q and detect whether the current $node$ satisfies formulas (6) and (7). In the process of algorithm attempt, if the current $node$ does not meet the conditions, the two items immediately adjacent to it in its frequency band are merged, and all possible re-added to queue Q, at this time the δ value corresponding to the newly added node in the queue must be greater than the value corresponding to the original node. Therefore, it can be seen that the algorithm in this article $\delta = 0,1,\dots,(N-1)$ try to meet the requirements of formulas (6) and (7) in turn. It's sure that the calculation is optimal for the cause that δ try from small to large.

4 Simulation experiment

In this paper, the interference resource allocation algorithm models the application scenario and realizes the optimal solution under the model through BFS. In order to verify the performance of the interference resource allocation algorithm, this paper designs a simulation experiment to verify the algorithm. The details are as follows:

The experimental data are randomly generated at the total frequency band of 200MHz, the number of frequency bands is between 10 ~ 20, and the number of frequency points in each segment is 30 ~ 70. A total of 1000 groups of experimental data were generated. The number of jammers T is between 4 and 6.

The manual selection of methods adopts the direct allocation method, that is, a methods of assigning directly from the beginning of the frequency until the end of interference resource allocation. The measure of this allocation is still the same as shown in Equation (7).

The performance index of the algorithm uses the index shown in formula (7). δ_1 and δ_2 are the corresponding indexes of the interference resource allocation algorithm and the manual selection of methods in this paper.

Simulation experiments were conducted in three groups. Experiment on the performance of the two algorithms at $T = 4,5,6$, respectively. The simulation results are shown in table 2-table 4. The data in the table is the number of samples that the simulation results correspond to at different δ_1 and δ_2.

Table 2. Number of corresponding experimental samples when $T = 4$.

δ_2	δ_1				
	0	1	2	3	4
3	38	3	1	0	0
4	363	117	80	22	4
5	154	85	62	40	14
6	2	4	9	1	1

Most of the samples in Table 2 are distributed in smaller locations δ_1. For example, $(\delta_1, \delta_2) = (0,4)$, $(\delta_1, \delta_2) = (0,5)$ and $(\delta_1, \delta_2) = (1,4)$, occupying a total of about 63.4% of the samples.

Table 3. Number of corresponding experimental samples when $T = 5$.

δ_2	δ_1					
	0	1	2	3	4	5
4	18	4	2	0	0	0
5	224	89	79	51	9	1
6	105	96	117	81	46	13
7	8	13	9	19	8	5
8	0	0	2	1	0	0

The combination of $\delta_1 = 0,1,2$ and $\delta_2 = 5,6$ in Table 3 occupies 71% of the samples.

Table 4. Number of corresponding experimental samples when $\boldsymbol{T = 6}$.

δ_2	δ_1						
	0	1	2	3	4	5	6
4	10	5	3	1	0	0	0
5	101	72	75	54	28	6	1
6	61	88	104	130	91	34	8
7	5	14	19	23	31	23	8
8	0	0	0	1	2	0	2

A similar conclusion is drawn in Table 4, where most of the samples are distributed in $\delta_1 = 0,1,2,3,4$ and $\delta_2 = 5,6$.

From the experimental results, all samples meet the requirements $\delta_1 \le \delta_2$. The conclusion is consistent with the algorithm in this paper. The algorithm is the optimal algorithm under the model. In addition, it can be seen that for most samples, δ_1 much less than δ_2, that is, for most cases, the algorithm in this paper will achieve significant advantages. When the value of δ_2 is larger, the gap of δ_1 and δ_2 will be reduced.

5 Conclusion

This paper presents an interference resource allocation algorithm, which mainly solves the problem that the interference frequency of the same jammer is as close as possible when allocating interference resources. In this paper, the interference frequency is divided into sections. The model believes that the frequency in the same band is close, while the different frequency bands are far away. In this model, an interference resource allocation algorithm based on BFS is proposed. Simulation results show that the algorithm has significant index advantages over the manual selection of methods.

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