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Multi-Agent Aviation Search Task Allocation Method

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Abstract. The multi-agent technology is used to reasonably allocate the search area determined after the aircraft crash, and the research on the task assignment problem of aircraft crash area based on multi-agent system is proposed. In the simulation experiment, the model of multiple rescue points, single disaster points and multiple emergency resource allocations is shown. The results show that the method can optimize the allocation of the search task in the aircraft crash area and dynamically change with the change of the crash area. The aircraft's search-assisted decision-making system provides some support.

Keywords: aviation search; multi-agent system; resource allocation

1 Introduction

The search after the aircraft crash is the last guarantee to ensure the safety of the aviation industry. The establishment of an efficient aircraft search assistant decision system can greatly reduce the loss of life and property. The main tasks of the aircraft search aid decision system include determining the search area.[1]And the rules for the allocation of search resources. The search area is determined by calculating the initial search area by the aircraft's last report of the latitude, longitude and speed of the crash location. The search area is determined based on whether the aircraft is found to be wrecked and survivors. The allocation rule for aviation search resources is the most The optimal allocation model, in the time of the aircraft's wreckage search and rescue[2], develop a corresponding search plan, and complete the optimal search resource allocation in the shortest time to ensure the safety of life and property to the greatest extent.

In recent years, artificial intelligence technology has developed rapidly. At present, Multi-Agent System (MAS) technology has been derived. Multi-agent systems can take synergy between multiple agents.Each agent can be an independent individual and interact with other agents to establish a new development plan or solution. Multi-agent theory has been applied in task allocation in the early years. In 1980, Smith established a contract network protocol for task assignment, which differentiated multi-agent systems into managers and collaborators, enabling dynamic task assignment.[3].

Introducing multi-agent system into the aircraft's search-assisted decision-making system, the problem of resource allocation can be further solved from the interaction of multiple agents. At the same time, the task assignment method based on multi-agent system is studied, and the mathematical model of auction rules is established. The traditional auction rules are combined with the multi-agent system to achieve the optimal resource allocation method for aviation search and rescue.

It can be seen from the above research that the multi-agent task assignment method based on the auction rule mathematical model has a wide range of applications in the field of maritime search and rescue, but it is rarely used in aircraft search assistant decision-making systems. Therefore, this paper proposes to apply the auction rule algorithm to solve the task allocation problem of aircraft search area,

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and design a multi-agent air search task allocation method based on the mathematical model of auction rules. This method of allocation not only satisfies the needs of basic aircraft search, but also adapts to the aircraft search area to dynamically change with the identification of some aircraft wrecks and survivors, and can use the limited search resources of aircraft crashes to achieve optimal search resources. Distribution, has a strong practicality in practice.

2. Task assignment model

2.1 Auction Rules

Auction is a basic economic phenomenon in human society[3]The seller formulates the corresponding bidding rules, the buyer bids according to the rules set by the seller, and finally the highest bidder is the successful bidder.There are many forms of traditional auction rules. This article uses the rules of unilateral auction, that is, a single seller, multiple buyers, the seller is the air search and rescue mission after the crash, and the buyer is the search and rescue force around the search and rescue area.

Introduce the multi-agent system into the traditional auction rules. When starting the task assignment work, consider the factors such as the profit and cost of the bidder[4], and make the bidder's price as much as possible while ensuring the maximum profit of the bidder. Decrease, increase the difference between the bidder's return and the cost, that is, increase the net profit of the bidder, and get the best task allocation plan at this time.[5]

The auction rule a can be changed with the seller, and the auction plan under the multi-agent system should be dynamically changed with the change of the auction rules.During the adjustment process, it is necessary to continuously update the algorithm scheme, and strive to calculate the task arrangement with the most benefit and the least cost in a short time.

Mathematical model based on multi-agent system auction rules

Au=<A, B, C, D, E, F>, where:

a represents the seller'sauction task, A is a collection in the traditional auction rules, a={A₁,A₂,....,A_n} is a positive integer; B is a collection of auction agents, which is a collection of agents that auction the task, B={B₁,B₂,....,B_n}, n is a positive integer; C is a collection of auction agents, C={C₁,C₂,....,C_n}, n is a positive integer; D is the benefit collection of the buyer's successful auction, D={D₁,D₂,....,D_n}, is a positive integer, wherein the auction agent in the auction agent collection B corresponds to the auction task in the traditional auction task collection A, the auction agent in the auction agent collection C, and the auction benefit in the benefit collection D. E is the collection of the price of the auction for the auction, which is the price for each auction agent to complete the auction task, E={E^{A_i}_{B_j}}, i<n, j<n, and both are positive integers; F is the auction price collection of the bidders, F={F₁,F₂,....,F_n}, n is a positive integer.

So in the mathematical model of the auction rules, when $\sum_{i=0}^{n} \sum_{j=0}^{n} (D_{i-} E_{B_j}^{A_i})$ When the maximum value is obtained, the bidder at this time is the optimal task assignment method. In the formula, we can see that when the difference between the bidder's return and the cost is the maximum, then the bidder gets the maximum net benefit of the task, which is the optimal task allocation method. The auction process based on the multi-agent system is shown in Figure 1.



Figure 1Auction process based on multi-agent system

2.2 Aircraft search task allocation principle

After the aircraft crashed, the Search and Rescue Coordination Center received the information and launched search and rescue work. After the Search and Rescue Coordination Center determines the search and rescue area, the search and rescue mission is released to the search and rescue forces within a certain range from the search and rescue area. The multiple search and rescue forces are their respective bidding agents, and the auction information is released to form a set of bidding agents.

2.3 Basic principles of auction assignment

The primary indicator of aviation search and rescue is fast. The time after the aircraft crash is life. Assigning the search and rescue mission to the professional forces around the crashed area within a limited time is the basic principle of the aircraft search task allocation method.[6]

Set the rescue response time after the aircraft is set to t, and the average moving speed of the surrounding rescue equipment is set to v. The center of the search and rescue area of the crashed aircraft is taken as the center, and the effective distance issued by the search and rescue mission can be obtained with the radius of v*t/2.Search and rescue forces within this distance can participate in the auction of aircraft search missions. If the search and rescue force is too small or the search and rescue requirements are not met within this distance, the scope of the auction information will be expanded to find a suitable bidder.

2.4 Aircraft search task allocation process introducing auction rules

In addition to the basic time to reach the search and rescue area, the task allocation method of the search area after the aircraft crash should also consider the comprehensive factors. The search and rescue capabilities, search and rescue speed, search and rescue costs of the bidding agent can be comprehensively considered into the benefits and costs of the bidding agent. Finally, the appropriate bidding agent is selected within the effective time to complete the search area after the aircraft crash. Initial task assignment.

With the introduction of multi-agent system auction rules into aircraft search task assignments, the new distribution process is shown in Figure 2.



Figure 2 Aircraft search task allocation process introducing auction rules

2.5 Dynamic adjustment of search tasks

The search area will be dynamically adjusted according to whether or not the aircraft is found to be wrecked and survivors. At this time, the published search task needs to be adjusted to achieve the optimal allocation of search power.

The dynamic adjustment of the search task is divided into searching for the search area and part of the search area by searching for the wreckage and survivors of the plane to complete the search for the initial bid search area. If the search area is expanded, the expanded search area is released as a new task to the surrounding search forces, and the new tasks are distributed according to the auction rules to ensure the distribution of search resources. If the search force completes the search task, it can apply to the search and rescue coordination center for searching for the bid search area[7].

3. Multiple rescue points, single disaster points, and multiple emergency resource allocation models

In this question, there is a single disaster point and multiple rescue points are needed. For example, serious natural disasters in a local earthquake require various types of emergency resources. However,

due to the destruction of local emergency reserve resources, it is necessary to mobilize emergency resources from neighboring cities for rescue. This is the typical multi-rescue point, single disaster point, and multiple emergency resource allocation problems. The road network structure of this problem is shown in Figure 3.



Figure 3 Road network structure of multiple rescue points, single disaster points, and multiple emergency resource allocation problems

4. Task assignment simulation experiment

In the simulation experiment of the search area task assignment after the aircraft crash based on the multi-agent system auction rule, multiple sets of search power comparisons are set, and the best search and rescue plan is obtained by sorting the final calculated bid price.

The influencing factors of aviation search and rescue forces are divided into: 1 the time required to reach the aircraft crash zone (determined by the ratio of distance to speed, in the simulation experiment, the assumed distance is 100km); 2 the maximum moving speed of the search rescue force; 3 the maximum range[8]. According to the access data, the data in Table 1 is obtained:

Influencing factor Name, model	(1)	2	3
AW119Kx	0.35h	282km/h	954km
AW109SP	0.32h	311km/h	859km
AW139	0.32h	310km/h	1061km
Airbus helicopter h130	0.35h	287km/h	617km
Airbus helicopter h135	0.35h	287km/h	635km
Airbus helicopter h145	0.37h	268km/h	680km
total	2.06h	1745kn/h	4806km

 Table 1 Data on the influencing factors of rescue forces

The stratification method is used to sort these influencing factors as follows: 1) the speed of reaching the aircraft wrecked area; 2) searching for the moving speed of the rescue force under the premise of ensuring the efficiency of search and rescue; 3) the maximum voyage; 4) loading the rescue equipment.

Normalize the above parameters, and get Table 2:

Influencing factor Name, model	1	2	3	Auction price
AW119Kx	0.170	0.161	0.198	0.529
AW109SP	0.155	0.177	0.179	0.511
AW139	0.155	0.176	0.221	0.552
Airbus helicopter h130	0.170	0.162	0.128	0.46
Airbus helicopter h135	0.170	0.162	0.133	0.465
Airbus helicopter h145	0.180	0.162	0.141	0.483

 Table 2 Auction price ranking of agents

It can be seen from the above calculation results that after the bidding agent is sorted according to the auction price from high to low, the highest bidding price is selected for the search and rescue force, that is, the helicopter of the model aw139.

5. Conclusion

This paper proposes an aviation search task allocation method based on multi-agent system auction rules. This method can select the best search and rescue force to participate in the search action for the actual situation of the aircraft crash in a short time, and the dynamics occur in the search area. When changing, the task assignment method can be dynamically changed with the change of the search task, and the search efficiency after the aircraft crash is continuously improved. According to the simulation result, the assignment of the search and rescue task can be completed quickly after the actual aircraft accident occurs, which has strong practicability.

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