Research on Route Planning Method of Dual Aircraft Rescue Based on Block Chain Technology

Lifeng Liu

College of Architectural Engineering, Shandong University of Technology, Zibo 255000, China
hebeiliu@163.com

Abstract. The dynamic change of rescue environment after disaster can greatly improve the efficiency of rescue by adjusting flight routes in real time according to the latest rescue environment and rescue tasks detected by aircraft. In this paper, the block chain technology is used to complete the real-time transmission of dynamic tasks and environmental information, and then the AI algorithm is used to realize the dynamic adjustment of flight route: realizing the real-time adjustment of flight route under the circumstances of dynamic change of rescue mission and deterioration of planning environment; the experimental results show that with the real-time transmission of threat information, threat detection and processing are realized, and threat information is localized. In this way, the transmission time of threat information and mission information and command center is shortened, and the efficiency and reliability of rescue are improved.

1. Introduction

Large-scale natural or man-made disasters usually cause in calculable losses to people's lives and property [1]. How to collect accurate information of people trapped in disaster areas is very important to determine the next step of rescue operations. However, due to the destruction of infrastructure and the paralysis of conventional communication networks, the commonly used disaster relief measures have been greatly limited, and aircraft aviation rescue has become a vital way of disaster relief. At present, UAV formation flight is a technology pursued by military and scientific researchers all over the world [2]. The key technical issues include formation design, aerodynamic coupling, dynamic adjustment of formation, route planning, and information exchange and formation flight control strategy. At present, it is the research hotspot of every UAV R&D power. After the occurrence of large-scale natural disasters, the infrastructure of disaster-stricken areas has been almost completely destroyed, which makes the traditional communication network unable to be used normally [3]. So how to use the limited communication resources to complete the post-disaster relief work is of great significance.

At present, most of the research on route planning methods focuses on the route planning methods in static environment. Route planning methods are generally divided into two categories [4]: exact route planning algorithm and heuristic algorithm. Among them, Dijkstra algorithm will increase exponentially with the increase of the scale of the problem, and heuristic algorithms such as A* can be powerful enough in computer computing nowadays [5]. Under the condition of larger scale and higher complexity, there are few studies on route planning methods in dynamic environment at present. Therefore, it is of practical significance to plan flight route in dynamic environment after disaster to improve rescue efficiency.
2. Route Planning Algorithms Based on Block Chain Method

In recent years, block chain [6] technology has attracted great attention from academia and industry. The main feature of block chain technology is decentralization, which is a global credit protocol based on cryptographic algorithms. When applied to route planning, block chain is a distributed information transmission chain technology based on the Internet, which can realize multi-party information sharing and ensure the change of information signs after the completion of threats or tasks. In this paper, block chain technology is applied to route planning of supply multi-UAV, and a dynamic multi-center Cooperative Route Planning Model Based on block chain is proposed.

According to the construction principle of block chain structure, with the increase of block chain, the cost of transmitting information will increase. By adding threat or task information into block chain, the core technology of block chain is encryption technology [8-11]. The use of block chain protocol can solve the credit problem of information transmission. In order to ensure the security of information, it is necessary to encrypt the transmitted information. According to the pre-agreed encryption/decryption method, the dynamic information can be parsed smoothly. With the completion of the task, the task flag can be modified in time to avoid the repeated execution of the task. However, because the attacker does not know the protocol of encryption and decryption of the task information and the agreement of whether the task is completed or not, it is difficult to complete the modification of the block information. The timely transmission of the task information in the block chain achieves its goal-decentralization mechanism.

![Flow chart of dual aircraft route planning based on block chain technology](image)

In this paper, the post-disaster rescue mission is realized by the cooperation of two planes. Firstly, an aircraft carries out rescue and reconnaissance tasks according to the original plan, and adds the real-time change information of mission planning area into the block chain in time to realize the rapid transmission of information. The same group of aircraft changes the route planning conditions according to the latest mission information on the block chain, and adjusts the fixed flight route in time. The specific route planning process is shown in Figure 1.
3. Experimental simulation

This experiment is in the airspace of 60 km *60 km. Two planes (A and B) are scheduled to fly from (1 km, 8 km, 300 m) and (10 km, 1 km, 300 m) to the same place (60 km, 60 km, 150 m) to carry out post-disaster rescue missions. Airplane A flies to the disaster area first to carry out rescue missions, and is responsible for the investigation of flight threats along the way, and for the latest flight threat information in the detected airspace. The latest information of rescue mission is uploaded to the block chain to provide information guarantee for safer and more efficient execution of the remaining rescue tasks.

In this paper, the topographic threat model $H(x, y)$ of the study area is constructed from the hypothetical peak data (its parameters are shown in Table 1) by formula (1):

$$H(x, y) = \sum_{i=1}^{m} h_i e^{-((x-x_0)^2 + (y-y_0)^2) / y_n^2}$$

In the above formulas, $m$ denotes the number of peaks, $h_i(x, y)$ denotes the height of the first peak, $(x_{oij}, y_{oij})$ and $(x_{sij}, y_{sij})$ denote the plane coordinates of the first peak and the parameters that descend along the $x, y$ directions, respectively. On the basis of this threat model, the parallel artificial immune algorithm (PAIA in brief) is applied to calculate the three-dimensional flight path of A and B aircraft which meets the flight requirements and has the lowest flight cost (see figure 2). The set of track points $\{x_i, y_i, h_i| i \in (1, n)\}$ (where n represents the number of track points). The calculation formula is as follows:

$$H(x, y) = \min(\sum_{i=1}^{m-1} h_i + (x, y) - h_i(x, y))$$

In formula (2), min denotes the function of calculating the minimum value, which is used to calculate the minimum value of the airline elevation difference.

According to the difference of threat detection and mission information, the flight route of B aircraft is re-planned in the following three situations: (1) The departure location of B aircraft has changed from (10 km, 1 km, 300 m) to (1 km, 1 km, 150 m) due to the temporary change of mission, while the disaster relief location of B aircraft is unchanged (60 km, 60 km, 150 m). Planning The departure route is shown in Fig. 3; (2) The location of B plane's mission has changed: as the original rescue has been completed by A plane, and A plane found new disaster areas in the course of its mission, the location of B plane's mission has changed from the original (60 km, 60 km, 300 m) to (50 km, 50 km, 150 m); (3) The planned new three-dimensional flight route is shown in Fig. 4; (3) The location of B plane's mission has changed from the original (60 km, 60 km, 300 m) to (50 km, 50 km, 150 m), Threat distribution in rescue airspace has changed: because of the destruction of earthquake and other disasters, there will be new threat factors affecting flight safety, such as house damage, landslides, temporary telecommunication stations, etc. This experiment assumes that a communication tower with a radiation radius of 25 km will appear at (30 km, 3 km), which has a certain impact on the original flight route, requiring B aircraft to fly. The flight route should be adjusted accordingly. The flight route can be planned as shown in Fig. 5.

3.1. Change of start point

For the first case, a plane finishes the scheduled local rescue task, and obtains the last block by using the existing block chain violent solution method. The hash algorithm is used to encrypt the information sequence (x, y, h, flag) to the end of the block, where (x, y, h) is the three-dimensional coordinate of the task point, in this experiment, it is (60 km, 60 km, 300 m), flag. To mark the completion of the mission, the value of 0 is to indicate that the rescue mission has not been completed, and the value of 1 is to indicate that the rescue mission has been completed. The second aircraft detects the emergence of new information sequence blocks in the block chain, and also reads the content of information blocks through violent cracking, and judges whether to adjust the flight mission according to the flag value. Because the A plane has completed the scheduled rescue mission, in order to simplify the complexity of information transmission, it is agreed that the units of X and Y coordinates are miles, the units of elevation are meters, and flag has no units. It uploads (60, 60, 300, 0)
to the block chain. The B plane discovers the information after decrypting the sequence blocks, and plans the flight route according to the current location.

Fig. 2 3D two-plane route planning by PAIA  
Fig. 3 3D route re-planning after B aircraft’s departure

3.2. Change of end point
In view of the second situation, because the rescue task is less than expected, the A-plane has completed the rescue task of the scheduled A-plane and B-plane itself. At the same time, the disaster situation in the existing disaster area is investigated. The locations found are (50 km, 50 km, 150 m) where the rescue needs to be carried out, and the information sequence blocks (50, 50, 150, 0) are implemented according to the method of experiment 1. Uploaded to the end of the block chain, B aircraft detects that new information sequence blocks appear in the block chain. It also reads the content of information blocks through violent cracking, and adjusts the mission according to the flag value of blocks. New rescue mission points (50km, 50km, 150m) were determined, and parallel artificial immune algorithm was used to plan flight routes.

3.3. Change of environment
Aimed at the third situation, A plane finishes the scheduled local rescue mission, but finds the temporary communication tower which affects flight safety during the rescue mission, and uploads the information sequence (30, 3, 25 000, 0) to the end of the block chain according to the method of experiment 1. B plane detects that new information sequence blocks appear in the block chain, and also communicates. The content of information block is read by violent decoding method, and the flight route is adjusted according to the flag value of the end block. According to the latest threat information, a threat model is added and a parallel artificial immune algorithm is used to plan flight routes.

4. Conclusion
Based on the results and discussions presented above, the conclusions are obtained as below:
(1) The application of block chain technology in the information transmission of dual-aircraft aviation rescue is analyzed from the angle of information change of mission starting point, mission point and threat distribution in rescue work.

(2) Block chain technology is integrated into the process of route planning. The global route planning algorithm is divided into three parts: static airspace dual aircraft flight route planning, dynamic airspace threat survey, dynamic information block chain upload stage and dynamic airspace single aircraft route re-planning. The dual aircraft route planning in airspace is transformed into the optimization problem among nodes with performance constraints, and the optimal route of aircraft planning is obtained based on parallel artificial immune algorithm.

(3) The simulation results show that the shortest safe flight path in dynamic airspace is suitable for the latest mission and threatening environment, which verifies the feasibility of the algorithm. The flight route in the whole airspace can be planned before the rescue mission is carried out, which makes the flight management more convenient, and reduces the inaccuracy of man-made real-time planning. The planning algorithm effectively reduces the risk of aircraft flight path. Therefore, it not only saves the cost of energy consumption, but also improves the efficiency of aircraft rescue, which helps to promote the development of aviation rescue towards a more intelligent, efficient and energy-saving direction.

Acknowledgments
This work was financially supported by Shandong provincial key research projects (2017GSF22105).

References
[1] Wang Qiuhua. Research and design of networking algorithm based on mobile terminal for disaster relief [J]. Chengdu: University of Electronic Science and Technology, Master's Degree Thesis, 2016.

[2] Wang Xiaoyi. New trend of future air combat: mixed combat between manned and unmanned aerial vehicles. NetEase [citation date 2015-09-04], http://war.163.com/14/0421/17/9QCE94L000014J0G.html? __pc=1.

[3] Li Luyin. Data forwarding strategy and Simulation in opportunity network in disaster relief environment [J]. Xiangtan: Hunan University of Science and Technology, Master's Degree Thesis, 2016.

[4] Liu Can. Research on Key Technologies of Web GIS Path Planning [D]. Tianjin: Tianjin Normal University, Master's Degree Thesis, 2014.

[5] Zhao Huachuan. Design of Dynamic Route Planning Method Based on Real Meteorology [D]. Harbin: Harbin Engineering University, Master's Degree Thesis, 2017.

[6] KAVANAGH D, MISCIONE G. Bitcoin and the block chain: a coup d'état in digital heterotopia?[C]/The 9th International Conference in Critical Management Studies: Is there an alternative? Leicester. c2015.

[7] Zhu Jianming, Fu Yonggui. Dynamic multi-center collaborative authentication model of Supply Chain Based on block chain [J]. Journal of Network and Information Security, 2016 (1), 2 (1), 27-33.

[8] NAKAMOTO S. Bitcoin: a peer-to-peer electronic cash system [EB/OL]. https://bitcoin.org/bitcoin.pdf.

[9] BUTERIN V. Ethereum white paper[EB/OL]. https://github.com/ethereum/wiki/wiki/White-Paper.

[10] Blockchain: the next big thing[EB/OL]. http://www.economist.com/news/special-report/21650295-or-it-next-big-thing.

[11] Gao Guowei, Gong Zhangli, Li Yongxian.. Research on the Government Basic Information Cooperative Sharing Model Based on Block Chain, E-Government, 2018, 182 (2): 15-25.