UAV Design and Control with A* algorithm

Yanzhuo Lin[1,*], Chenhan Feng[2,a], Zhixin Wang[3,b], Zhiyuan Wang[3,c]

[1]Hangzhou Weihan School, Hangzhou, Zhejiang, China

[2]Northwestern Polytechnical University, Xi'an, Shanxi, China

[3]Suzhou Science & Technology Town Foreign Language School, Suzhou, Jiangsu, China

[a]2739873718@qq.com, [b]henrywang1201@outlook.com, [c]tonywang1201@outlook.com

*Corresponding author: 2862309436@qq.com

These authors contributed equally to this work

Abstract

With the changes of the times, the logistics industry is developing rapidly. Transportation is a vital part of the logistics industry. Surveys have shown that transportation costs often account for more than half of the cost, and the use of drones can greatly reduce transportation costs , so reasonable path planning is essential. In the UAV path planning , be sure to make the UAV can accurately avoid obstacles. This article will be based on the A* algorithm , to find out between two of the most UAV flight between the good path. Computer simulation experiments show that the proposed testing the use of the algorithm can effectively solve the UAV obstacle avoidance path planning.

Keywords

UAV, path planning, A* algorithms, logistics and transportation.

1. Introduction

UAV industry as an important technological innovation of our country , is in a stage of development spurt . Its technology is becoming more and more mature , capable of performing complex and dangerous tasks . It is mostly used in military investigations, electric power inspections, cargo transportation, logistics distribution, etc. , and has a place in the aviation field. At the same time, with the rapid development of automation control technology, sensor technology, and other technologies , the functions of UAV have become more and more perfect , and the application fields have continued to expand . Therefore , it is of great significance to study the problem of UAV path planning.

2. The prospects of UAV

The rapid development of China's logistics transportation industry , has become an important part of our national production , the daily closely related to people . However, with the increase of market demand , the cost of logistics distribution is also increasing . Reasonable and effective transport solutions , not only can help companies reduce transportation costs , improve the quality of transport , while still achieving energy saving and environmental protection targets [2] . UAVs because of its efficient, flexible and low cost , and gradually by the major logistics company's preference. Countries in the world in the UAV pilot or distribution services to diversify forms , US Amazon as early as 2013 Nian put forward in a short time with the UAV within 5 pounds distribution idea goods , 2017 Nian 2 Yue UPS -free HMI distribution test , at the top of the delivery truck loading UAVs , and the like after reaching the vicinity of the consignee address , by the UAV courier delivery , may 30 perform delivery tasks within minutes . Iceland Aha in 2017 Nian 8 Yue use Israeli UAV company

ISSN: 2414-1895 DOI: 10.6919/ICJE.202112_7(12).0028

Flytrex service , in Reykjavik, Iceland launched an on-demand food delivery service. 2016 Nian , Jingdong own research and development of a variety of UAV products to be held in Shanghai CES Asia as well as the number of Expo held in Guiyang debut. Xiao Jun, vice president of Jingdong said , the rural delivery costs 5 times in the city , while the drone can be solved to this problem.

When it comes to logistics and transportation, it has to mention the problem of UAV obstacle avoidance and path planning. Road path planning issue has been a hot research scholars , UAV path planning was originally developed by the traveling salesman problem and vehicle routing problem Evolution from . The problem of UAV obstacle avoidance path planning is generally divided into two-dimensional and three-dimensional situations . This paper mainly studies the path planning problem of two-dimensional plane .Path planning algorithms are of utmost importance for the flight path of UAVs. Many scholars have done excellent research in this area.For example, lattice methods[7], symbolic planning methods[8], trial-and-error methods[9], and knowledge inference methods[10] are used for planning.

Among them methods such as simulated annealing, genetic algorithms and ant colony algorithms are superior for random search, whereas in our logistics transport we use deterministic state space search and therefore can use the A* algorithm.

Path planning is the regulation of the flight path. It is a key element of the UAV's advanced planning system and begins with trajectory planning. Trajectory planning is the calculation of optimal and sub-optimal flight paths so that the drone can move safely and avoid enemies.

However, the process of implementing drone route planning requires special consideration due to the economic and practical requirements of drones and the special nature of separating man from machine. For example, as the UAVs are unmanned, control and management are distributed between the geographically distributed UAVs and the control stations, so that in the event of an unexpected event, management and control personnel are unable to solve the problem in the first instance. Furthermore, due to lags and delays in the processing and transmission of data chains, drones are unable to fully execute their planned routes using human-machine interaction.

Therefore, given the current level of development of computer technology and the constraints of economy and engineering practicality, UAVs used for logistics couriers, unlike those used for combat or other purposes, have certain characteristics of the route planning problem that can be simplified accordingly in some respects.

3. Problem description

The problem studied in this article is to find the shortest path from the end to the starting point of the UAV through the A* algorithm, and after avoiding obstacles, the shortest path is obtained.The flight environment and endurance time have certain restrictions. In order to ensure that the drone can deliver items to the designated location, it is necessary to plan its path. Also, because the drone is in a flying state, obstacles and obstacles that are less than the flying height can be ignored. For pedestrians, set it as a simple two-dimensional plane for consideration and path planning. This article uses a two-dimensional map for path planning.

There are several requirements for UAV path planning:

1. The starting point and ending point of the drone, the placement of obstacles.

2. The result should be a path from the start point to the end point, and the path must not pass through obstacles.

3. The shortest path should be selected as much as possible, considering the life time and range of the UAV under realistic conditions.

The main way to realize the path planning is to transform the real environment into a two-dimensional plane map through the modeling of the environment, and grid it according to a certain proportion, and transform the actual space into the virtual space of the computer. , The buildings etc. are expressed in the form of coordinates. Find a path in the computer that avoids obstacles, reach the destination and the shortest distance, and display it on the computer.

The purpose of this article is to find the shortest path while avoiding obstacles to realize logistics transportation.

This article will mainly discuss the realization of A * algorithm.

4. Algorithm principle

Use the A* algorithm to design and plan the flight path of the UAV, and to find the shortest path, we first grid the map, and set the starting point and the end point based on the distribution of the buildings on the original map in the grid-processed map. And obstacles, create two arrays of open and close to store node information, open list is the points that can be used for path planning, and close list is the points that meet the requirements of path planning. In path planning, we choose:

F=G+H

To find the best path. G=The cost of moving from the starting point to the specified square, along the path generated by reaching the equation, is the straight-line distance between the two points; H= The estimated cost of moving from the specified square to the end point, the calculation method is The sum of the difference between the end point and the abscissa of the node ($|x1-x2|+|y1-y2|$) . The method of generating our path is: repeatedly traversing the open array and selecting the square with the smallest F.

Save the node coordinates in open , move to the parent coordinates of the node , the value of F , G , H

Set an appropriate map size and mark the location of each point.

The starting point and end point of the obstacle into the use Close List , use Close List coordinate location of the point of saving. And put the starting point into the open list .

Repeat the following steps:

Traverse the open list , select the node with the smallest F , and use it as the currently processed node

Move this node into the close list

Select the points around the node (3*3), determine whether each point is an obstacle or an end point, if not, put the point in the open list , find the point with the smallest F , and put it in the close list . Until the end point is placed in the open list .

Set the end point as the parent point, and look for the smallest point of G that reaches the starting point in reverse , and define it as the new parent point until the next parent point is the starting point.

Connecting the parent points is the optimal path. If the end point cannot be placed in the open list , the path does not exist.

The simulation experiment process is realized by the Matlab programming language, and Matlab is used to map the planning environment and the planned trajectory . We Zhejiang University, Zijin Campus, for example, Figure 1 plane campus map, it is subject gridding process, which is divided into a grid of 50 * 40, and shows the range and obstacles, after Matlab in To restore replication, first put the start point, end point and obstacles in the close list, then select the start point and put them into the open list, analyze the points around them one by one, calculate the size of F, G and H, and put them into the open list , Then select the point with the smallest F and place it in the close list. Repeat the above steps until you find the end point, and then set the end point as the parent point. Among the points around it, that is, the closest point to the current parent point in the close list Find the point with the smallest G within the points of, set this point as the new parent point, repeat the above steps, connect all parent points, that is, the optimal path. The optimal path is shown in Figure 2.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202112_7(12).0028

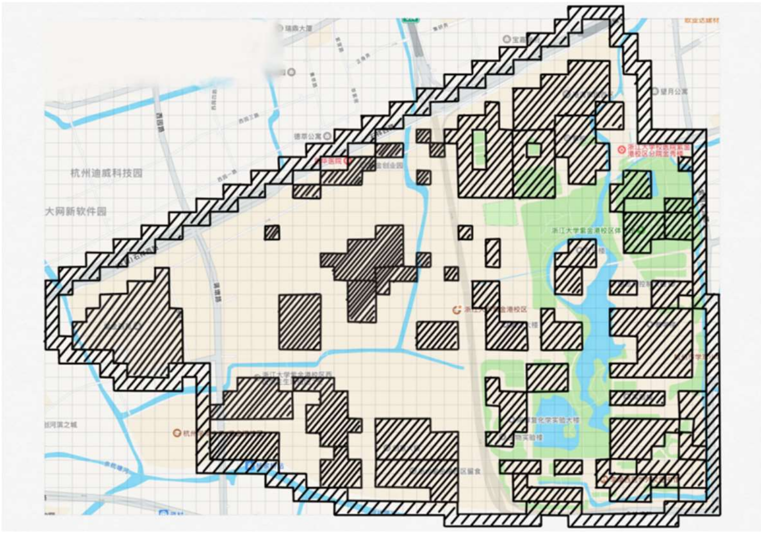

Figure 1: Zhejiang University, Zijin Campus

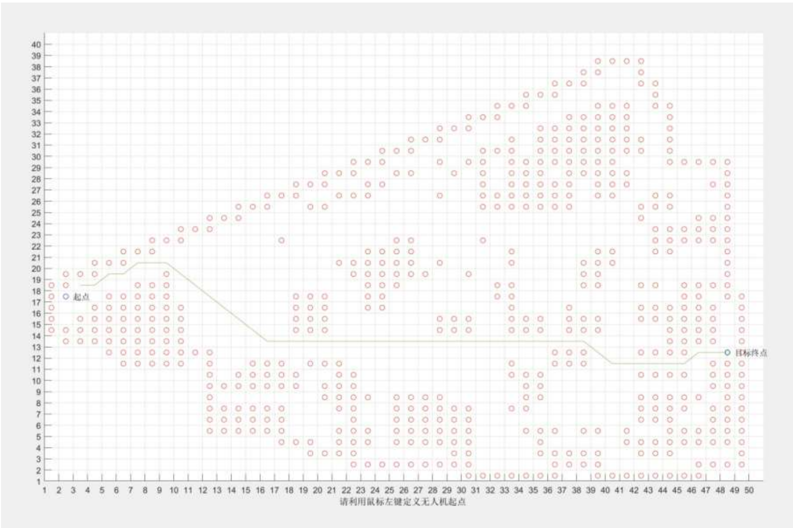

Figure 2: optimal path

5. Pseudo-code

Input: Information of start_node, obs_node, target_node;

Output: best path;

open list[], close list[], path cost F, exp_array[], surround node;

open[] ← start_node;

close[] ← obs, target;

while (node is not target)

select the current node;

select any surrounding node;

while (the node is not the last surrounding node)

if (the node is not obstacle)

calculate F of node;

exp_array[] ← node;

open[] ← exp_array[];

if end;

select the next surrounding node;

while end;
if (the node is not obstacle)
calculate F of node;
exp_array[] ← node;
open[] ← exp_array[];
if end;
node_min ← find the smallest F value of the node from open list;
close[] ← node_min;
while end;
if (path exist)
draw the best path;
else
show"path doesn't exist";
end if;
End.

6. Concluding remarks

This paper realizes UAV path planning using A * algorithm, which can get the best path of UAV movement in an environment with obstacles. However, this method also has certain shortcomings. For example, this method cannot realize the collaborative work and real-time path planning of multiple drones. The implementation of this algorithm is also relatively simple, unable to judge emergencies, can only move according to the established route, and need to update the map situation from time to time. It is also more cumbersome in the initial setting. If there are many obstacles, repeated labeling will consume a lot of time and cost. In the future, we will study the path planning problem in the case of multiple drones working together. We will also try to copy the map directly, save and import the map, reduce time cost, make the program more concise and complete, and further improve Path planning in complex environments.

References

[1] GOODCHILD A,TOY J.Delivery by drone:An evaluation of unmanned aerial vehicle technology in reducing CO2,emissions in the delivery service industry[J]. Transportation Research Part D:Transport and Environment, 2017.

[2] Xia Liu. Research on Vehicle Path Problem [Doctoral dissertation]. Wuhan: Huazhong University of Science and Technology, 2007.

[3] Xiaohui Li,Miao Miao, Baojian Ran, Yi Zhao , Gang Li . UAV obstacle avoidance path planning based on improved A* algorithm. Computer System Applications,2021,30(2):255-259.

[4] Yanmei Dong. Design of Port Logistics Development Model Based on Supply Chain Management: A Case Study of Jiangsu Coastal Ports[J]. Special Economic Zone, 2010(10).

[5] Hui Gao, Xin Chen ,Yuncheng Xia . Research on UAV flight path planning[J]. Journal of Nanjing University of Aeronautics and Astronautics, 2001(02).

[6] Changan Liu. Research on UAV flight path planning method [D]. Northwestern Polytechnic University, 2003.

[7] Willoughby. J, et al. Optimzation approaches to Route planning for cruise missiles. A79-50061.

[8] MacMillan T. R. Knowledge Based Route Planning. Proc. of IEEE 1990 NAECON, 1001−1007.

[9] Millar Robert. J. An Artificial Intelligence Based Framework For Planning Air Launched Cruise Missile Missions. AFIT/GCS/ENG/84D-17, 1984.

ISSN: 2414-1895
DOI: 10.6919/ICJE.202112_7(12).0028

[10] Jardine.T.J.Knowledge Representation in Automated Mission Planning. AIAA Computers in Aerospace IV Conference, 83-2317.

[11] Ma Liang , Xiang PJ. Application of ant algorithm in combinatorial optimization. Journal of Management Science" J], 2001.