ISSN 2706-655X Vol.4, Issue 5: 1-5, DOI: 10.25236/IJFET.2022.040501

Research on Forest Fire Rescue Path Planning Based on Improved A* Algorithm

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Abstract: *Forest fires are known as one of the eight natural disasters in the world. They are sudden and destructive, have a profound impact on the living environment of human beings, and cause serious damage to the atmosphere. Therefore, once a forest fire occurs, how to plan the path in the first time so that the firefighters can climb the distance from the nearby highway to the location of the fire is of practical and urgent significance. Based on the introduction of innovative NDVI and slope weight factors, this paper normalizes and superimposes the relevant factors by improving the A* path planning algorithm, and obtains an optimized pathfinding algorithm. Experiments show that the planning of forest fire rescue paths is highly feasible.*

Keywords: *Forest Fire, Weighting Factor, Path Planning, Shortest Distance, Improved A* Algorithm*

1. Introduction.

There are an average of 220,000 forest fires in the world every year, and the affected area reaches 10 million hectares, accounting for about 0.1% of the total forest area. It is also listed as one of the eight natural disasters in the world. At present, both developed and developing countries still lack effective control methods for forest fires that occur under extreme weather conditions after prolonged droughts. At the same time, large-scale forest fires account for 3% of the total forest fires, and the losses caused by them are more than 80% of the total forest fire losses [1]. Therefore, in the face of such a strong threat of natural disasters, how to get fire rescue workers to the fire site in the first time after the fire has occurred will become the top priority of emergency management work. Therefore, the study of path planning will become a necessary way to solve this problem.

By borrowing and improving Dijkstra's algorithm, A-star algorithm establishes a mathematical model based on heuristic search strategy, which changes the disordered search in Dijkstra's algorithm and has become the mainstream algorithm for grid path planning.[2]. This paper intends to improve the parameters of the A* algorithm, so that it can be better applied to the rescue path planning of forest fires in mountainous areas.

2. A* Algorithm Introduction and Analysis

The A* algorithm is the most effective method for solving the shortest path in static networks. The algorithm uses the heuristic function to optimally select the nodes to be expanded, so that the expanded nodes are less than other similar search algorithms, so it is more efficient. In addition, its heuristic function The features of flexible design and easy implementation are very suitable for optimal path calculation of grid terrain. If h(n) is 0, then fn and g(n) are equal. At this time, the A-star algorithm becomes Dijkstra's algorithm, which can guarantee to find the shortest path. [3]. the A* algorithm calculates the priority of each node using the following functions:

$f(n)=g(n)+h(n)$.

Where:

Among them, f(n) is the estimated cost of transitioning the initial state through state n to the target state, g(n) is the actual cost of transitioning from the initial state to state n, and h(n) is the minimum cost of transitioning state n to the target state. If h(n) is always less than or equal to the cost of moving n to the target node, then the A-star algorithm is guaranteed to find a shortest path. And the smaller h(n) is, the more points the A-star algorithm needs to expand, the slower the running speed, and the lower the running efficiency of the algorithm. If h(n) is exactly equal to the cost of moving from n to the target node, then the A-star algorithm will only follow the best path and will not expand to any other nodes, and can run very quickly. At this time, the algorithm has the highest operating efficiency and operating quality. If h(n) is more expensive than moving from n to the target node, the A-star algorithm will not necessarily find a shortest path, but it can run faster. At this time, the running quality is poor. At the other extreme, if h(n) is much larger than g(n), then h(n) determines f(n), and the A-star algorithm evolves into a greedy best-first search algorithm. It can be seen that the selection of the heuristic function must be different according to the application type. [4]. By adjusting the heuristic function we can control the speed and accuracy of the algorithm. Therefore, the A* algorithm not only finds the optimal solution with a great probability, but also reduces the redundant time.

During the operation of the A* algorithm, the node with the smallest f(n) value (the highest priority) is selected from the priority queue as the next node to be traversed. The classic A* algorithm basically stores nodes in three states around two open sets and closed sets, details as follows:

Stepl: Put the start-node into the open table; and prepare to start executing the first layer of loop logic;

Step2: The first layer of loop logic starts, and the node with the smallest f value in the open table is taken out as the current-node, and the following processing is performed. If the current-node does not exist, the pathfinding ends in failure. If the current-node is the end-node, the pathfinding ends successfully, and the predecessor node of the end-node is set to the current-node, and then returns to the end-node to deduce its predecessor node in reverse order, until all the start-node A path consisting of nodes is returned.

Step3: Add current-node to the close table;

Step4: The second layer cycle is ready to start;

Step5: Traverse the adjacency-nodes of the current-node one by one, and do the following processing; if the adjacency-node is in the closed table, do nothing. If the adjacency-node is not in the open table, update its g value and h value; set the predecessor node of the adjacency-node as the current-node node, and finally add the adjacency-node to the open table. If the adjacency-node is already in the open table, compare whether the g value from the current current-node to the adjacency-node is better than the g value of the adjacency-node at this time.

If it is not better, do nothing; if it is better, update the g value of adjacency-node to the g value from current current-node to adjacency-node, and change the predecessor of adjacency-node to current the current-node node

Step6: Go back to Step5 to continue processing the next adjacent node.

Step7: As long as the open table is not empty, go back to Step2 for processing.

3. Improvement of A* Algorithm based on Mountain Forest Fire Rescue Path Planning

Introduce the slope and NDVI (Normalized Vegetation Index) factors, which are important to the path planning of mountainous woodland, as weights, normalize the slope and ndvi from 0 to 1, and then superimpose pixel by pixel to generate a weight map. The weight is in the range of 0~2. The normalized vegetation index represents the denseness of trees and grasses in the mountains. The denser the trees and grasses, the more difficult it is for natural firefighters to move forward. At the same time, the size of the slope will also affect the difficulty of moving forward.

4. Experimental data

4.1 Image Data Sources

91 Satellite Image Assistant is the world's first professional downloader for Google Earth satellite images, historical images and elevations, and it is also the downloader with the strongest technical strength and the best user reputation in China [5]. So far, this software has been adopted by more than 10,000 enterprises and institutions in many industries including surveying and mapping, saving a lot of costs for customers, bringing huge value, and producing huge economic and social benefits.

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As a pioneer and leader in the field of Google Earth data download in China, this software has realized the complete interpretation of the Google Earth data transmission protocol (the only one in China that can achieve complete analysis). It perfectly realizes the efficient download of massive high-quality images, elevations, and historical images. Different from other downloaders on the market, this software supports efficient download of massive data of any size and format in the world. The downloaded data has no Google watermark, no offset, and has a clear shooting date. It also supports the download of global historical image data from the 1930s to today, and can be selected by the date specified by the user. In addition, the software also supports mass download of global elevation data and vector road network data.

The software also supports the download of more than 100 types of maps, images and terrain data provided by mainstream map vendors at home and abroad, such as Bing Maps, ArcGIS Online, OpenStreetMap, Baidu Maps, AutoNavi Maps, etc., to meet the needs of customers to the greatest extent. In addition, the software supports WGS84 coordinate system, Xi'an 80 coordinate system, Beijing 54 coordinate system, national 2000 coordinate system, local independent coordinate system and other coordinate systems and projections, and can be used with AutoCAD, ArcGIS, CASS, MapGIS, Eardas, GoogleEarth, Professional software such as Cesuim and OruxMaps are seamlessly connected, which greatly meets the needs of professional users.

4.2 DEM Data

USGS and NGA develop vastly improved global elevation model----2010 Global Multi-Resolution Terrain Elevation Data[6].For the elevation data of this paper, use this.Use ArcGIS software to obtain the elevation and slope information of Beijing area.

4.3 NDVI Data

Download Landsat imagery via Geospatial Data Cloud and calculate via NDVI = (NIR-R)/(NIR+R)

Among them, NIR: the reflectance value of the near-infrared band R: the reflectance value of the red band. The range of NDVI is always -1 to +1. It is one of the parameters commonly used by many scholars to monitor vegetation growth, crop growth and reflect vegetation quality. [7].

5. Study Area

Comparing with the township zoning map of Beijing, it is found that Tanghekou Town in Huairou District is located in a mountainous area with many forests and is suitable as a research area for route planning. The terrain of Tanghekou Town is high in the northwest and low in the southeast. The terrain is divided into three types: plains, hills and mountains, river valleys and valleys, but it is mainly mountainous terrain, and the terrain in the south of Tanghekou Town is dominated by plain landforms. Tanghekou Town belongs to the warm temperate semi-humid continental monsoon climate, which is characterized by four distinct seasons, cold and dry in winter, warm and humid in summer, short in spring and autumn, and long in sunshine.

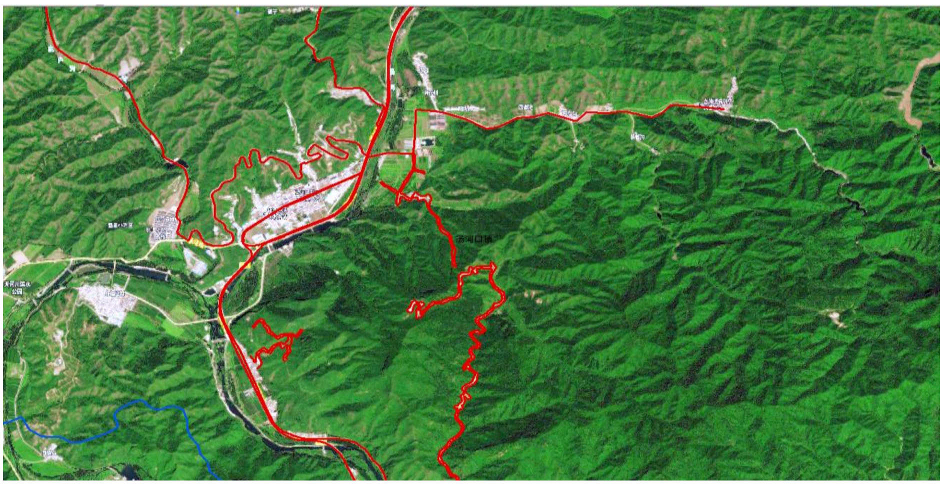

Figure 1: Tanghekou Town, Huairou District, Beijing, research area.

According to the Google Earth satellite image, the image of Tanghekou Town is obtained by cropping. Then use arcgis software to draw the road of Tonga Estuary Town in vector, and then perform raster conversion as the road planning layer.

6. Experimental Results

Based on the python program, using numpy to calculate the matrix and the image extension package PILimage to combine the slope and NDVI factor of the DEM to conduct experiments. As shown in the figure below, enter any coordinates in the program to assume the location of the fire, and get the route planned. This route successfully selected areas with sparse trees and grasses and gentle slopes as the rescue path up the mountain.

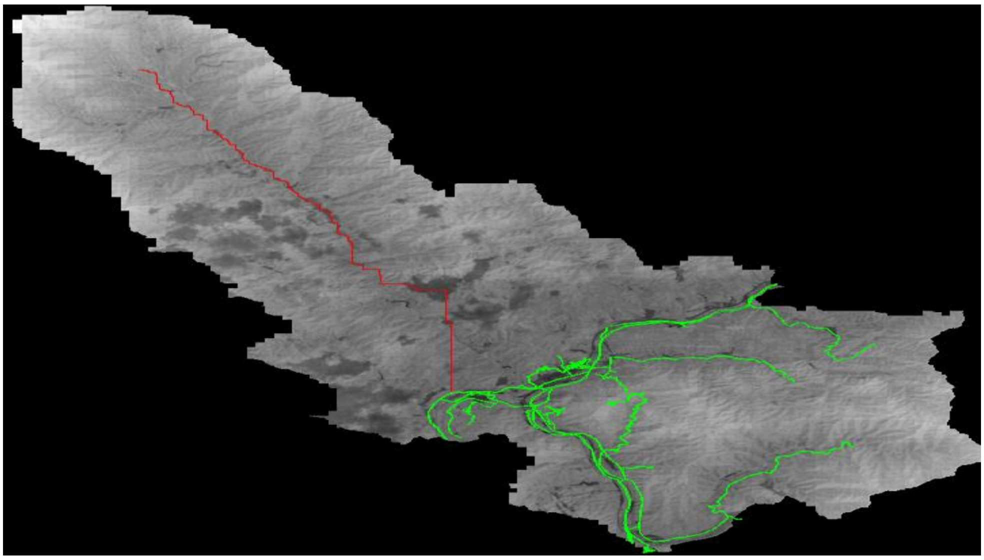

Figure 2: After inputting the coordinates of the fire point (100, 100) in the program, calculate and process, and get the best path for fire rescue

7. Conclusion

It can be seen from the above simulation experiments that the improved A* mountain forest fire path planning algorithm is obtained by normalizing and superimposing the slope factor obtained based on DEM data and the NDVI factor obtained from the LANDSAT satellite image. The rescue of mountain forest fires is highly feasible. The size of the slope and the denseness of trees and grasses during the journey will affect the difficulty of moving forward during the rescue process. Choosing a route that minimizes the impact of the two will naturally reduce the time consumed during the journey. Buy more time for fire rescue and reduce more losses.

Acknowledgments

This work was supported by scientific research project of Beijing Education Commission (Z20006, Research on quality detection method of land cover classification based on depth confidence neural network).

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ISSN 2706-655X Vol.4, Issue 5: 1-5, DOI: 10.25236/IJFET.2022.040501

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