Scientific Journal of Technology Volume 3 Issue 11, 2021
ISSN: 2688-8645

UAV Obstacle Avoidance Path Planning Based on Binocular Stereo Vision

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Abstract

With the widespread application of drone technology, people can buy drones at relatively low prices. One of the main applications of drones is aerial photography. In order to pursue better aerial photography effects, the camera equipment carried by drones is becoming more and more sophisticated. In order to ensure the service life of unmanned aerial vehicles and avoid damage to valuable aerial photography equipment, efficient path planning methods are increasingly being valued by scientific researchers. This paper is based on binocular stereo vision technology, combined with improved A* algorithm to plan UAV obstacle avoidance path.

Keywords

Stereo Vision; Unmanned Aerial Vehicle; Obstacle Avoidance Planning.

1. Introduction

Traditional obstacle avoidance methods often use infrared technology. However, if infrared technology is used for obstacle avoidance [1] in UAV, it will increase the weight of the UAV on the one hand, and increase the cost of the equipment on the other hand. This article combines the existing UAV with multiple cameras, and applies binocular stereo vision technology to establish a three-dimensional scene, so that UAV can obtain depth perception. With improved A* algorithm. The obstacle avoidance path planning [2, 3] is carried out on the basis of almost no need to increase other equipment.

2. Construction of Binocular Stereo Vision System

The more important thing to build a binocular stereo vision system is the calibration of the binocular camera, and various corresponding coordinate systems must be established before the camera is calibrated.

2.1. Establish A Coordinate System

2.1.1 Camera coordinate system

The camera coordinate system is represented by the coordinate system composed of the origin O and the XcYcZc axis, where O is the optical center of the camera. The camera coordinate system is established with O as the origin, in which there is an Xc axis parallel to the x axis of the imaging plane coordinate system, and a Yc axis parallel to the y axis of the imaging plane coordinate system. The optical axis of the camera is represented by the Zc axis. The schematic diagram of the camera coordinates is shown in Figure 1.

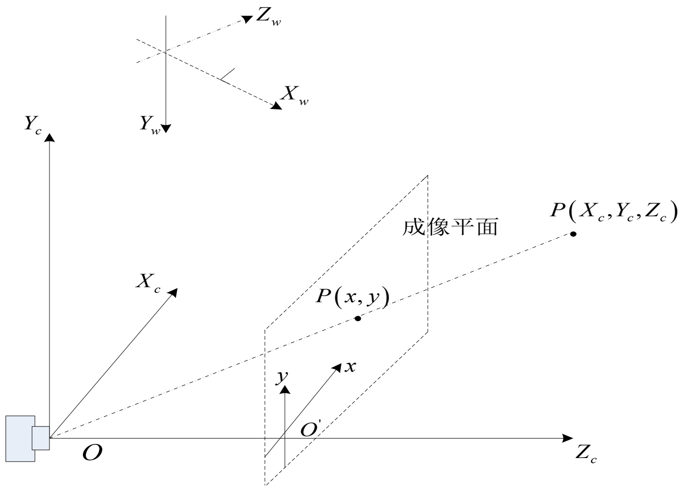

Figure 1. World coordinate system

In order to describe the positional relationship of the coordinate system, the establishment of the reference coordinate system is very important. People usually establish a world coordinate system as a reference coordinate system. The conversion relationship between them can be expressed by the following formula.

$$\begin{bmatrix} X_c \\ Y_c \\ Z_c \\ 1 \end{bmatrix} = \begin{bmatrix} R & t \\ 0^T & 1 \end{bmatrix} \begin{bmatrix} X_w \\ Y_w \\ Z_w \\ 1 \end{bmatrix} = M_1 \begin{bmatrix} X_w \\ Y_w \\ Z_w \\ 1 \end{bmatrix} \tag{1}$$

2.1.2 Camera calibration

The most common and easy-to-understand model of camera models is the pinhole model. According to the principle of small hole imaging, the objects in the scene emit light or reflect light from other light sources through the lens of the camera and then appear on the imaging plane. The line connecting the principal point O1 of the imaging plane and the optical center is called the optical axis, where the coordinate system of the imaging plane is composed of the principal point O1 as the origin, and the u and v axes. The Xc axis of the camera coordinate system is parallel to the u axis of the imaging plane coordinate system, the Yc axis is parallel to the v axis of the imaging plane coordinate system, and the Zc axis also coincides with the optical axis. When the light reflected by a point P on the object to be photographed is projected onto the imaging plane through the optical center O of the camera, its projection position coordinates are P(x,y). It is easy to know from the imaging relationship of the lens that the image on the imaging plane is the reflection of the shooting object. In order to facilitate the analysis, we establish a virtual imaging plane through the geometric relationship, and the objects photographed on this plane are no longer "reflections". The virtual imaging plane coordinate system is a coordinate system with O'as the origin and the axis. The positional relationship is centered on the optical center O and is in a symmetrical relationship with the imaging plane.

2.1.3 Basic Principles of Binocular Stereo Vision

The binocular stereo vision system consists of two cameras with different viewing angles. Any point P (X, Y, Z) in the space is projected onto the imaging planes Cl and Cr of the left and right cameras respectively. The image coordinates of the projection point on the left camera are pl (ul, vl), and the image coordinates of the camera on the right are pr (ur, vr). These two image points "match" each other. Although there are two imaging points, these two points are both

ISSN: 2688-8645

images of point P(X, Y, Z). That is, the point P(X,Y,Z) is on the line connecting the point pl(ul,vl) and the optical center Ol of the left camera, and the point P(X,Y,Z) is also at the point pr(ur,vr) and On the connection of the optical center Or of the right camera. The intersection of the two lines is the space point P(X, Y, Z). The structural model of binocular stereo vision is shown in the figure2.

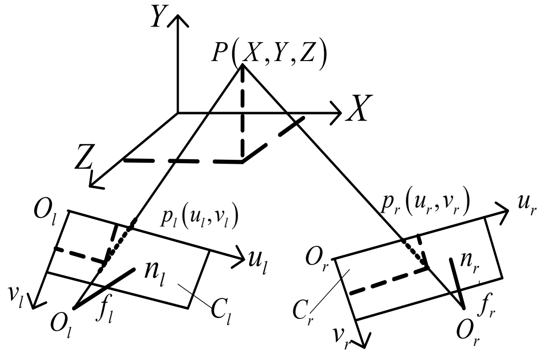

Figure 2. The structural model of binocular stereo vision

3. The Improvement of A* Algorithm

The core of the A* algorithm lies in the design of the valuation function, as shown in the following formula:

$$f(n) = g(n) + h(n) \tag{2}$$

Among them, g(n) is called the dissipation function, which means the actual cost from the starting node to the node; h(n) is called the heuristic function, which means the estimated cost from node n to the target node; f(n) means the cost from the starting node The estimated cost from node n to the target node. Similar to the Dijkstra algorithm, the A* algorithm also maintains an Open table. The priority of the nodes in the Open table is arranged according to the size of f(n). The smaller the value of f(n), the higher the priority of the search. In order to ensure that the optimal solution can be searched, the heuristic function h(n) cannot be too large, and cannot be greater than the actual cost from node n to the target node; but if the heuristic function is 0, the A* algorithm degenerates to the Dijkstra algorithm, although it can be guaranteed to be The optimal path; but the algorithm efficiency is low; if h(n) is exactly equal to the actual cost from node n to the target node, then the node explored by the A* algorithm is exactly the node on the optimal path. The value of h(n) in this article is the common Manhattan distance.

Improve the original A* algorithm. First, if the parent node of the current node and the child nodes are on the same straight line, the node is considered to be a redundant node, and the changed node is deleted. This reduces the number of judgment nodes.

Secondly, set the acceptable change angle α. The straight line formed by the current node and the parent node and the straight line formed by the next two child nodes, if the angle formed by the two straight lines is less than the acceptable change angle α. The node is considered redundant.

ISSN: 2688-8645

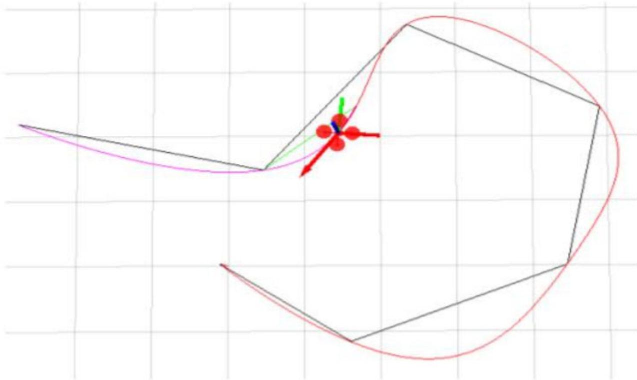

Figure 3. Path planning after removing redundant points

The above figure characterizes that the efficiency of the original algorithm has been significantly improved and the speed of obstacle avoidance has been significantly increased due to the obvious reduction of the amount of calculation after the redundant points are screened out.

4. Summary

Obstacle avoidance and path planning of UAV are crucial in UAV technology. This article combines the feature of carrying multiple cameras in the existing UAV technology. Using binocular stereo vision technology to construct a three-dimensional image field of the target, starting from the basic imaging principle of the camera, the basic model of the camera is systematically explained. Which mainly analyzes the basic principles and concepts of the linear model of the camera and the difference between it and the nonlinear model of the camera. The structure and principle of binocular stereo vision model and two types of binocular stereo vision system are introduced. The drone can perceive the depth information in the scene. At the same time, the traditional obstacle avoidance algorithm is improved, because the traditional obstacle avoidance algorithm calculates all the points to be scanned. In this paper, multiple redundant points are removed by setting multiple rules, which greatly enhances the efficiency of path planning and improves the ability to avoid obstacles.

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