Review of 3D reconstruction technology of UAV aerial image

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Abstract. The construction of "smart city" is the development direction of major cities. It is an important part of the construction of "smart city" to reconstruct urban buildings, land and roads into three-dimensional models through three-dimensional reconstruction technology. In this paper, the image-based three-dimensional reconstruction technology and UAV path planning technology are described, hoping to use UAV aerial images for three-dimensional reconstruction, and carry out relevant research on the three-dimensional reconstruction of outdoor large-scale scenes.

Keywords: UAV; aerial photography; 3D reconstruction; path planning; algorithm

1. Introduction

With the rapid development of China in the past 30 years, the demand for 3D data in geographic information, urban construction, national defense and other fields is growing. The traditional two-dimensional information can no longer meet the needs of national construction and people's daily life. At present, China's development in the field of geographic information is backward. When collecting geographic information data, rural and remote areas mainly rely on manpower to draw and mark on the spot, which not only requires a lot of manpower, material resources and financial resources, but also has great errors in drawing geographic data information. In such a situation, in order to break through many difficulties to achieve 3D modeling of geographic information and city, we need to further study and expand the current 3D reconstruction technology and theory, so that the scene of large data set can be automatically reconstructed.

With the rapid development of UAV related technology in recent years, UAV has been widely used in various fields of society with the characteristics of small volume, low energy consumption and high mobility. Compared with traditional photogrammetry and remote sensing platform, UAV has great advantages as a measurement platform. In practical use, UAV has the advantages of low cost, simple operation, no route restrictions and other methods in geographic data acquisition. The combination of low altitude flight and high-resolution lens greatly exceeds the requirements of digital city for three-dimensional image accuracy. Through the formation flight of UAV, a large number of UAVs can be used to collect data in a region at the same time, which greatly improves the efficiency of data collection. Therefore, UAV is the best platform for 3D reconstruction data collection at this stage.

The process of 3D reconstruction can be regarded as the inverse process of camera imaging, which restores the 3D structure of scene or object from 2D image. Three dimensional reconstruction is a hot research field, which integrates computer aided geometric design, computer animation, image processing, virtual reality, digital media, parallel processing and other technologies, and integrates computer simulation, computer vision, computer graphics and other disciplines. At present, 3D
reconstruction technology has entered a stage of rapid development, and has been widely used in many social fields, such as virtual environment, augmented reality, archaeology, urban planning, robot, film industry and so on. According to the different methods to obtain the depth information of the target object, three-dimensional reconstruction can be divided into active method and passive method.

2. Image based 3D Reconstruction Technology

Image based 3D reconstruction is mainly based on the feature matching between images, epipolar constraints and multi view constraints to solve the coordinates of 3D points. The whole reconstruction process has the characteristics of large amount of calculation and complex process.

The idea of reconstructing 3D scene based on image was first proposed by Marr in the 1970s. In 2001, Marc et al. Proposed a 3D scene reconstruction system based on uncalibrated images captured by a hand-held camera. The system uses the matching features between images to express the relationship between images, and achieves ideal geometric reconstruction effect on both synthetic and real data.

In 2008, Noah and others used the photos of famous scenic spots collected from the Internet to restore the three-dimensional point cloud and camera shooting position of scenic spots, so that users can browse the photos of scenic spots in a new way. Bundler, a 3D reconstruction framework developed by them, takes several unordered images as input, which can reconstruct the 3D sparse point cloud structure of the scene and restore the position and orientation of the camera in the scene. On the basis of their work, goesele et al. Proposed an improved multi view stereo vision algorithm. The input of the algorithm is also the image of world-famous scenic spots from the Internet community. The intermediate result is a number of depth maps with high accuracy. The dense point cloud representation of the scene is obtained by merging the depth maps. Their algorithm can deal with images with great differences in illumination, scale, occlusion conditions, etc., by selecting the appropriate matching image pairs to eliminate the influence of adverse factors as far as possible, in order to reconstruct an accurate building model.

Arnold et al. Proposed an efficient method for image registration into 3D scene. This method can register the video frames recorded in real scene into the scene point cloud, and calculate the camera position during video shooting. The experimental results show that the method can get the moving track of camera in indoor and outdoor scenes.

Furukawa et al. Proposed a multi view stereo vision algorithm based on patch. The algorithm uses the mapping relationship between the small square patch with position and normal vector and the pixel grid on its visible image to restore the adjacent patch of the patch in three-dimensional space and realize the expansion of the existing patch to repair the gaps between patches to obtain dense three-dimensional model. The output of PMVs algorithm is dense points with directions on the surface of the model to be reconstructed, so Poisson surface reconstruction method is suitable for further obtaining the 3D mesh model of the object. The advantage of this method is that it can reconstruct a more realistic model, but the computational cost is very high.

Liu Peijun, a domestic researcher of Zhejiang University, proposed a building model reconstruction algorithm based on planar and cylindrical surfaces, which can recover the surface model of buildings from a single perspective image. In this algorithm, corresponding reconstruction methods are proposed for planar and cylindrical surfaces, and then the complete building model is obtained by merging multiple local models. The advantage of this algorithm is that it can reconstruct the surface model of buildings by using a small number of images, but the disadvantage is that the building model can only be approximately represented by planar and cylindrical surfaces, and it is not suitable for occluded building images.

Li Jie proposed a building model reconstruction method based on a single image. This method determines the perspective projection relationship between two-dimensional plane and three-dimensional space through camera calibration. On the basis of determining the base plane, it recursively restores as many planes as possible according to the geometric relationship between other planes in the image and the base plane, so as to complete the reconstruction of the model. The
advantage of this method is simple and small amount of calculation; the disadvantage is that the plane model representation of the building is too simplified and many details of the building are lost.

Luo Gonghui proposes an image-based urban building modeling method, which extracts the upper and lower edges of the building from the multi view panorama constructed by the image, and uses the structural characteristics of the building to repair the occluded building texture in the panorama, and finally obtains the building model. Compared with other methods, the data acquisition method of this method is simple and keeps the structural details of the building model to a certain extent.

The Institute of automation of Chinese Academy of Sciences has developed a 3D reconstruction system called cvsuite based on the principle of stereo vision. This system collects three images of the same target from different angles, then matches the features of the three images through the feature points in the image, and reconstructs the 3D model of the target by combining with the camera self calibration.

In 2016, baidu map launched the 3D real map of three scenic spots, including huaguiyuan. It takes images from the sky of the scenic spot by UAV, and then realizes the 3D model map of the scenic spot through image-based 3D reconstruction. From the map, you can view the 3D model from multiple angles. On the whole, the reconstructed model has good integrity, and the building has no deformation. From the details, there are distortion and dislocation, the corners become smooth, and the trunks, poles and other cylinders appear dislocation. On the whole, Baidu's reconstruction effect in these three scenes is good, and the details and texture information are rich, which brings the research upsurge of 3D reconstruction in China.

3. UAV path planning technology

The UAV equipped with high-definition camera is required to control the flight direction and speed of the UAV and the orientation of the camera at the same time. It is difficult to get smooth video for a long time by manual operation. Therefore, the development of UAV aerial path planning algorithm and auxiliary tools is of great significance to improve the efficiency of aerial photography and the effect of aerial video. According to the application of UAV in different aspects, many methods have been proposed.

In 2014, foreign researchers such as Matthew proposed an effective algorithm for UAV cluster formation transformation in dense environment. The algorithm can simultaneously plan feasible paths for dozens of UAVs of the same type to make them transform between different formations, and its time complexity is proportional to the cubic order of the number of UAVs in the cluster.

In the aspect of aerial photographing of outdoor scenes, in order to cooperate with users to express their aerial photographing intention, Christoph and others proposed a set of advanced user interaction tools The algorithm generates the flight path and provides the flight preview in the virtual environment. The user needs to modify the key frame iteratively to get the desired trajectory. The disadvantage of the tool is that it has a high demand for devices and does not provide any guidance for the modification of keyframes.

In order to reduce user intervention, Roberts and others adjust the time of infeasible trajectory on this basis to make the trajectory meet the physical and dynamic constraints of UAV. The flight preview of their method in Google Earth virtual environment is in good agreement with the real flight effect.

Aiming at aerial photography of indoor scene, Mellinger proposed a method of pre planning the optimal flight path of UAV to cross the circle, aisle and other obstacles in crowded indoor environment. The input of this method is a series of key frames, and the generated flight path of UAV will pass through these key frames and avoid obstacles at the same time.

In 2016, Robin et al. Studied the problem of path planning for micro UAV in the interior with dense obstacles. Their method divides the interior space into several safe areas, and formalizes the problem as a mixed integer programming problem to solve. The final path is connected by piecewise polynomial paths distributed in these safe areas. After experimental verification, their method can make the UAV pass safely in the dense space containing poles and lines.
Domestic researchers have done little research on UAV path planning, but they have made some progress. Liu Li et al. Proposed a path planning method for small UAV, which uses particle swarm optimization algorithm to plan benchmark path, and uses improved * algorithm to realize online path planning. The simulation results show that the method can generate a feasible flight path in a short time. Aiming at the irregular obstacle space in the city, Zhang Qirui proposed a path planning method for UAV combining local backtracking and breadth first strategy. Simulation results show that the method can effectively guide UAV to avoid obstacles in dense space and improve the safety of UAV low altitude flight.

4. Conclusion

Three dimensional reconstruction based on UAV aerial images is the technical background of this paper. This reconstruction technology can realize the automatic reconstruction of the scene. In addition to the image set of the given scene, it does not need to provide other information, and can get good reconstruction effect. For geographic information, smart city, real estate and other industries, this reconstruction technology has advantages in practicability and reconstruction effect that other reconstruction algorithms do not have. 3D reconstruction algorithm based on UAV aerial images is a hot topic in the field of 3D reconstruction.

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