

A Survey of Image-based 3D Reconstruction

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Abstract. Image-based 3D Reconstruction is the inverse process of geometric drawing, however, the lack of information makes it difficult to reconstruct the 3D image. The methods of 3D reconstruction using object contour information contain manual interactive operation, stereo vision, motion image, photometric stereo. Based on the degree of automation of image-based 3D reconstruction technology, the difficulty of the algorithm and the quality of 3D reconstruction, the researchers analyzed and studied the advantages and disadvantages of various methods, respectively. Technical difficulties mainly in three aspects contain matching problems, precision problems, speed problems. The researches pointed out the challenges and the future development direction of the 3D reconstruction based on vision. This technology is still in the exploratory stage and there is a long way to put it into practice.

1. Introduction

3D reconstruction is widely used in object recognition, industrial automatic design, video game, animation, digital archives, original building restoration, etc. In the real life, 3D reconstruction is widely used in the field of computer vision. Refactoring has a higher efficiency to achieve real-time computation. The domestic and foreign scholars have made extensive and deep research on the theory and method of 3D reconstruction based on image, and have obtained a lot of useful research results. Although the theory of view geometry in image-based three-dimensional reconstruction has matured in recent years, many advances have been made in the research of image-based 3D reconstruction, such as optimality, robustness and efficiency. The quality of continuous improvement. It is these new algorithms and new results are emerging, making the three-dimensional image-based reconstruction is still a very active research topic.

At present, the market can see many excellent modeling software, more well-known 3Dmax, Maya and AutoCAD and so on. Their common feature is the use of a number of basic geometric elements, such as cube, ball, through a series of geometric operations, such as translation, rotation, stretching and Boolean operations to build complex geometric scene. The advantage of this method is that it can accurately construct 3D models of many artificial objects, especially buildings, furniture; can produce some exotic renderings, which is widely used in film and television works and advertising effects; In addition, it also allows people to better control the light and texture. The disadvantage is that, first of all, people must fully grasp the scene data, such as the size of the scene in the size of the object,

Relative position, the lack of such information is difficult to model

In this paper, a large number of references are used to study the three-dimensional reconstruction based on image. The popular three-dimensional reconstruction algorithms based on image are contrasted and analyzed, and their respective defects and applicable ranges are analyzed. In this paper, the image-based 3D Reconstruction method is divided into manual interactive operation method, stereo vision method, motion image method, photometric stereo method.

2. Manual Interactive Operation Method

Since most of the computer-based reconstruction methods are not very effective, the researchers proposed to increase the human interaction in the reconstruction process. By manually marking some feature points, some known parameters are input to reconstruct the three-dimensional surface. On the

one hand can make the algorithm is simple, on the other hand can also make the reconstruction of the better. A typical example is the 3DMewo 3D modeling software produced by BiVoirtual Inc., which generates a three-dimensional model of 3D with two face images of the front and side, plus a set of contour control points. The production process without any professional knowledge, and the process is extremely simple (only three steps can be), the effect is very good.

3. Stereo Vision Method

Computer stereoscopic vision is a technique that uses two or more cameras to image the same scene from different locations and thereby recover the depth (distance) information from the parallax. Computer stereo vision is the most important distance sensing technology in passive ranging method. It directly simulates the way of human vision processing scene, and can measure the stereoscopic information of scene flexibly under various conditions. Its role is other computer vision methods cannot be replaced, and its research, both from the perspective of physiological and engineering applications in both have very important significance.

Stereoscopic vision mainly uses the geometric principle to achieve three-dimensional information recovery, which is less disturbed by the physical properties of the scene. Therefore, the 3D information of the scene can be recovered more accurately. Observing the world, you can compare the left and right eye information to determine the difference between the relative depth of the object, this is because the two eyes in the point of view there are some differences, this phenomenon is called stereoscopic disparity. Stereo parallax simulation to achieve three-dimensional information recovery process, three-dimensional visual simulation. Projective geometry can be used to model stereo vision based on the spatial location of feature points on two objects of the same object.

4. Motion Image Method

The motion is described by the motion field, which consists of motion (velocity) vectors at each point in the image. We can obtain the corresponding image changes when the target moves in front of the camera or the camera moves in a fixed environment. These changes can be used to obtain the relative motion between the camera and the target and the mutual relations among the multiple targets in the scene. When relative movement between the camera and the scene object is observed, the brightness mode motion is called the optical flow. The optical flow can express the change in the image. It contains both the information of the movement of the observed object and the structural information related to it. The three-dimensional structure of the scene and the relative motion between the observer and the moving object can be determined by analyzing the optical flow. So by solving the optical flow equation, you can get the surface direction of the scene, thereby reconstructing the three-dimensional surface of the scene. The disadvantage of this method is the relatively large amount of computation.

5. Photometric Stereo Method

At the heart of the photometric method is the brightness equation of each point in the image, that is, the irradiation equation, the mathematical description is as follows:

$$I(x, y) = k_d(x, y) S \cdot N(x, y) \quad (1)$$

Where I is the brightness of the surface point, S is the light source vector, N is the surface normal vector, and k is the surface reflection coefficient. Equation (1) can only be a constraint, and the surface normal vector N has two unknown components, if there is no additional information cannot be based on the image of the radiation equation to restore the direction of the surface. Photometric Stereo Vision method is not changing the relative position of the camera, the use of different lighting conditions to obtain multiple images, resulting in a number of radiation equation. The normal vector N of the surface of the object can be obtained by solving the equation, so as to realize the 3D reconstruction. Since there is no change in the relative position of the camera and the object, there is no need for the matching calculation between the images. However, because equation (1) is an ideal relationship, where the

experience of kd is also very strong, so the actual effect will not be very good. The method is applied in the field of satellite remote sensing and landform restoration.

6. Comparison and Analysis

The theoretical basis of the above three kinds of image-based three-dimensional reconstruction methods is different from their degree of automation, the degree of difficulty of the algorithm, the quality of three-dimensional reconstruction, the time required for reconstruction and the areas of application to compare, as shown in Table 1:

Table 1. Method of Image-based 3D Reconstruction comparison

Method Based on 3D Reconstruction	degree of automation	Algorithm difficulty degree	3D reconstruction quality	The time required for 3D reconstruction	Field of application
Manual interactive operation method	Low degree of automation	Relatively easy to achieve	More accurate recovery of the object surface model	general long	The reconstruction of polyhedrons with plane composition. only a partial surface model can be obtained, not whole
stereo vision method	To the general extent of automation	Requires robust algorithms; harder to implement	Accurate recovery of the object surface model	long	For more simple surface reconstruction
motion image method	To the general extent of automation	Relatively easy to achieve	With the image acquisition density	very long	Generally applicable image acquisition density is relatively large, suitable for convex reconstruction
photometric stereo method	To achieve fully automated	Requires robust algorithms; harder to implement	Accurate recovery of the object surface model	very long	Reconstruction of two images taken with a camera with little matching

In addition, there are some new applications will also become the next period of time the research focus:

A) Non-rigid and dynamic three-dimensional reconstruction of objects "Traditional three-dimensional reconstruction method for the basic are rigid objects, non-rigid objects (such as liquid objects, flame) and dynamic objects such as reconstruction has not been able to achieve, Aspects of the problem will become a hot topic in the future.

B) Three-dimensional reconstruction of large-scale scenes it has been a difficult problem to reconstruct 3D scenes of natural terrain (including lunar and Martian terrain) and urban landscapes, and how to use satellite or aerial pictures to make these scenes fast and accurate. Of the reconstruction, is also a very valuable research direction.

C) Microscopic reconstructions of microscopic and microscopic objects, such as the use of endoscopes for medical purposes, are largely dependent on the experience of the physician and can be

more clearly demonstrated if they can be modeled using a miniature camera to capture images. The internal situation of the human body, help the doctor diagnosed. In addition, the use of electron microscopy for the reconstruction of biological macromolecules, to strengthen the relevant areas of research is also very valuable.

D) Recognition and understanding combined with artificial intelligence and other technologies, the use of reconstruction of the three-dimensional model for further pattern recognition and other applications.

7. Conclusion

Image-based 3D reconstruction technology is still in the exploratory stage, a variety of methods from the practical application of some distance, a variety of application needs to be met. Therefore, in the future for a long period of time, but also in this area more in-depth and detailed study.

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