Discussion on Application of 3D Reconstruction in Landfill

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Abstract—Objectively, intelligent landfill management is the development trend of solid waste and hazardous waste landfill. The purpose is to clarify the development status of 3 D reconstruction technology and provide technical support for the field area of landfill reconstruction. Considering the research status of 3D reconstruction technology, analyze the advantages and scene applicability of solid waste landfill characteristics and landfill operation requirements, summarize the applicable method of 3D reconstruction, and summarize the role of reconstruction technology in solid waste landfill risk avoidance to promote the fine and intelligent management of landfill. The paper will provide ideas for future in-depth research on landfill 3D reconstruction. This electronic document is a "live" template. The various components of your paper [title, text, heads, etc.] are already defined on the style sheet, as illustrated by the portions given in this document.

Keywords-solid waste landfill; 3D reconstruction; applicability; risk avoidance component

1 INTRODUCTION

Solid waste is characterized by large production and complex characteristics. Landfill is the most important means of safe disposal of solid waste. It is not only widely used in developing countries such as China and India, but also in developed countries and regions of solid waste that only has no utilization value. Although the new ideas and new technologies of waste treatment and recycling are constantly innovated, their treatment or recycling capacity still cannot solve a large amount of waste. Because of this reason, the amount of solid waste landfills in China will continue to increase substantially. However, due to the incompatible waste mixing and the disorderly stacking of waste with different mechanical characteristics, the safety accidents in the landfill site occur frequently, and the vast majority of solid waste landfills in China have great safety risks in the landfill management. Therefore, it is of great practical significance to study the accurate monitoring of piles in solid waste landfills [1,2].

Many scholars at home and abroad use various ways to confirm the positive impact of accurate reactor monitoring on the environment, mainly focusing on the nature of landfill waste itself, the stability of landfill slope and the calculation of remaining storage capacity. for instance, Due to the differences in the properties of the different types of landfill waste, Can cause instability inside the landfill body, Landslide, and uneven settlement, If severely ruptured the impervious layer, Leach fluid leakage, Polluting the groundwater, And then destroy the safety of the landfill; In order to master the strength parameters of reactor size and soil layer after

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waste landfill, The stability of the current pile slope, the subsequent pile slope and the foundation can be evaluated, Master the stability condition of the landfill body; Gao et al. divided the waste in the landfill into separate column units, A simplified, complete landfill process was used to determine the landfill process of each unit, The storage capacity of the landfill is calculated based on the hierarchical sum method [3].

Although the current 3D reconstruction methods have made remarkable achievements in specific fields and conditions such as surveying and mapping, unmanned driving, mobile robots, etc.[4,5], the complexity and difficulty of the monitoring task are caused by the complex and changeable working environment of the landfill site, high landfill frequency, fuzzy surface texture and other factors. From the existing literature, the research on precise monitoring of landfills through landfills is mainly focused on the initial stage, and the landfill progress has not been accurately calculated, and few scholars have conducted in-depth discussions on the management of landfills by attributes and zones.

In this paper, the selection of methods and specific operation procedures for precise monitoring of solid waste landfills are reviewed. Firstly, the basic concepts and research progress of 3D reconstruction are introduced, and the principles, advantages and disadvantages of general 3D reconstruction are classified; Secondly, according to the characteristics of the landfill itself and its surrounding environment, the reconstruction methods suitable for the solid waste landfill are selected, and the equipment selection, data collection, reconstruction steps and other aspects are introduced in detail; Finally, the application of the reconstruction method of solid waste landfill selected in this study in the field of precision monitoring is analyzed and summarized, and the direction of the heavy process of solid waste landfill to be studied is prospected, providing technical support for the monitoring of landfill capacity and risk identification.

2 PROGRESS IN COMMON 3 D RECONSTRUCTION

2.1 Basic theory of 3D reconstruction

At present, 3d reconstruction technology is a research hotspot in the field of computer vision and computer graphics, refers to in a given image data set or video through depth data acquisition, preprocessing, point cloud registration and fusion, generate surface process, the real scene into computer logical mathematical model, this model can be such as cultural relics protection, architectural design, clinical medicine research play an auxiliary role. In addition to reconstructing the 3D model from the input data, the multi-finger also provides a real-time visual interface, where users can intuitively see the 3D model of the scene from the current camera perspective.

There are a variety of the ways of reconstruction, the most mature way is the geometric modelling technology reconstruction, this is based on the human input geometric model to establish the corresponding 3D model, the method can generate accurate 3d model, but the process is complex, long modeling cycle, especially for irregular objects in nature, not only modeling is more difficult, and its accuracy cannot be guaranteed. In order to accurately reconstruct the irregular object, the coordinate information of the measured object is obtained through the acquisition device, and the measurement is divided into contact measurement and non-contact measurement according to whether the acquisition device contacts the measured

object. Contact measurement is mostly manual measurement or instrument measurement, with simple operation and stable algorithm. However, the problems such as irregular shape, large object measurement speed and large error are also highlighted. However, the non-contact type overcomes the limitations of the above shortcomings, without contacting the measured object, with no damage to the surface of the object, and gradually is recognized by people with its advantages of fast speed and high precision. Non-contact measurement is divided into active 3D reconstruction and passive 3D reconstruction (image-based 3D reconstruction) according to whether the acquisition equipment actively transmits measurement signals. Active 3D reconstruction needs to emit structural light source to the scene, and then calculate and extract the projection information of the light source in the scene to detect the target location and measure it, which is mainly used in biomedical imaging, cultural relics protection and other scenarios, and common 3D reconstruction, including laser ranging method, structural light method and time-of-flight method. Passive 3D reconstruction is not to use any other energy source, only by obtaining the reflection of the external light source for 3D measurement, using specific algorithms to calculate the three-dimensional space information of the object, including shadow recovery shape method, texture recovery method and motion recovery structure method. Passive 3D reconstruction can also be classified according to the number of cameras used, including 3D reconstruction based on monocular vision, binocular stereo vision and binocular stereo vision, in the fields of film, surveying and mapping.

2.2 Overview of the 3 D reconstruction study

2.2.1 Active 3D reconstruction:

Active refers to the sensor initiative to transmit signals to the surface of the object under test, rely on analysis and comparison of the target object emission signal and return signal (the signal including laser, electromagnetic waves and sound waves), through the target modulation reflection, using the time difference of return light or deformation information, estimate the depth of the surface of the object information, such as laser ranging method, time of flight method and structural light method, etc.

Laser ranging method is through device modulation laser beam and directional control, the object reflected light receiving and processing, time difference and distance, extracted data including 3D coordinates, intensity, color and time stamp, it has the advantages of strong anti-interference quantity, rich information acquisition, and in industry length, distance and 3D surface is widely used in the detection [6]. If the location of the image point on the light source and the sensor is known, the position of the image point can be calculated from the triangle relationship of the light source, object point and image point shown in the schematic diagram. Although triangulation method has developed relatively mature, it is greatly affected by the environment in the actual application process and the measurement speed is slow.

Time-of-flight (TOF) method is the method of diffuse reflection of a laser pulse beam emitted to the main surface of the object to be measured. The distance between the device and the surface layer can be obtained by recording the time difference between the transmitted and received signals. The time-of-flight method can be divided into direct and indirect measurements according to the mode of measurement of propagation time. It can be divided into pulse modulation and continuous wave modulation according to the type of light pulses modulated by the light source emitter. This method is widely used because of its simple

measurement principle and fast imaging speed, but the compact size, strong anti-jamming ability, high precision time sensor itself, high cost and low resolution, and high time cost. Therefore, low efficiency and poor real-time performance restrict the development of time-of-flight method.

Structural light method refers to the position relationship of the projector and the camera to decoding the 3D information of the object through stripes. The encoded beam generates the feature points to the smooth surface emission. According to the geometric model of the projected light, the distance between the camera light center and the feature point is calculated through the principle of triangulation, thus generating the depth information to realize the model reconstruction. Several types include point structure light, line structure light and encoded structure light. Because of the simple implementation and high accuracy, so it has become a widely used basic hardware equipment.

2.2.2 Passive 3D reconstruction:

Passive multiple refers to the use of natural light ambient light reflection, using the camera for two-dimensional image sequence, and then extract useful information, through the specific algorithm calculation object three-dimensional space information, the advantage of this method is wide application scenarios, can complement the active type, at the same time both the low price and strong real-time advantages, its deficiency is the reconstruction accuracy is not high. Picture-based 3 D reconstruction includes monocular, binocular and multilocular vision.

Monocular stereo vision is to only use a camera for 3 d reconstruction method, the image can be a single perspective of single or multiple images, it can also be multiple perspective, multiple images, mainly extract image brightness, depth, texture, contour, geometry, feature points and other features, the method is simple and convenient, cheap, and the processing time is relatively short, widely used in the field of detection.

Binocular stereo vision is to imitate the human eye, two same cameras observe the same object from two aligned perspectives, obtain the images of the left and right sides of the same position, using triangulation method to obtain the depth information of the object, and finally complete the 3 D model reconstruction of the object. The advantages of binocular vision method are that the technology is mature and the modeling results are superior, while the disadvantages are the large amount of operation in the modeling process and the low modeling effect in some areas. Wang Tao's graduation thesis is done in this respect.

Multilocular visual technology is a research from image acquisition to visual surface reconstruction of the new field, it is on the basis of binocular stereo vision development research, so the principle is similar to binocular vision, just distinguishing point is in the study of two cameras added one or more cameras, obtained the more perspective of the object at the same time. Through this method greatly reduces the visual blind area, expands the acquisition field, reduces the impact of the environment on the acquisition, so as to achieve the purpose of improving the accuracy. However, because of the increase of the number of cameras, the number of collected images also increases accordingly, and the increase of the computing amount leads to the increase of the reconstruction time.

3 ANALYSIS OF LANDFILL SITE CHARACTERISTICS AND REACTOR MONITORING REQUIREMENTS

3.1 Analysis of landfill site characteristics and reactor monitoring requirements

First, the type of waste disposed of by a solid waste landfill is solid waste, and the size and type of the landfill are known at the time of design and construction. Usually, the landfill scale scale is large, and its capacity setting can meet the operating period requirements of up to 10-20 years. Although a large amount of garbage can be temporarily disposed of through landfill, its deficiency lies in that it occupies a large land area and cannot effectively reduce the garbage. During the operation and even after the closure, a large amount of leachate caused by the rainfall and the degradation of the landfill itself is easy to cause large air, soil and water pollution. In order to control the amount of rainwater infiltrating into the landfill, the surface layer is laid with black rain proof film as a cover layer to reduce the amount of leachate production, and cooperate with the anti-seepage system in the landfill to achieve the purpose of harmless.

Second, the solid waste landfill leachate, harmful substances can cause inorganic pollution, organic pollution and composite pollution three categories, in the process of garbage degradation and settlement landfill leachate and reactor characteristics change, although is the same area of the garbage composition, concentration, distribution will gradually change over time, so the landfill leachate and reactor characteristics distribution law is more complex. There are many kinds and high content of heavy metals in the leach. Different types of waste are mixed due to insufficient disposal capacity, which will not only cause resource waste and potential environmental risks, but also bring about safety accidents such as explosion and uneven settlement of piles.

Finally, "recycling" refers to the extraction of the recovery from the solid waste useful material and resources, at present, Malaysia, Sweden, Britain and other countries are resources recycling work, but the current disposal means is not standard, many waste are temporarily stored in the landfill, which requires landfill to daily waste attributes, landfill and landfill location record, with the subsequent recycling comprehensive utilization technology is updated, can according to the record information will be filled waste treatment after the renewable resources utilization. Although the technology of using renewable energy for power generation and battery storage is more popular, it requires a high cost. If we calculate and predict the actual location and concentration of the material, it will have a positive impact on the actual landfill operation.

3.2 Selection of 3D reconstruction method of landfill body

This requires us to landfill the operation surface landfill entrance supervision. The main content of the supervision is to record the landfill increment of the landfill, obtain the storage capacity surplus, dispose the waste with different landfill properties in zones, and rationally make use of the precious resources of the storage capacity. At the same time, record the location of the landfill accurately, match the properties of the landfill, and avoid resource waste.

With the progress of 3D reconstruction technology, more scholars will focus their research to large-scale complex scenes, reverse express the shooting process, and realize the extraction

and establishment of 3D models from multiple 2D images collected in the field. Therefore, solid waste landfill supervision can be better assisted through 3D reconstruction.

The landfill covers a vast area, and the operation is divided into zones. The rainfall and temperature in different areas are different. Because the equipment works outside during the day, with long light time and changeable environment, the expensive active equipment works in such an environment for a long time, which has a serious impact on the life of the equipment.

Monocular camera acquisition method refers to the use of monocular camera from multiple angles to the same number of pictures, although does not contain image depth information, but can through the algorithm from the image camera posture information and object of 3D information, its high popularity, simple operation, low cost, also applies to large-scale complex scenarios. Therefore, the current 3D reconstruction of solid waste landfill field is based on the passive expansion of monocular camera.

3.3 Landfill site reconstruction method

Assuming that the images of a certain area of the landfill in our hands are collected by the continuous movement of the camera, so we need to use the different position information of the camera to calculate the posture information of the camera and recover the key information of the scene. Scholar Pollefeys has summarized the multi-view recovery and reconstruction process of uncalibrated images, including five steps: feature extraction and matching, multi-view geometric constraint relationship calculation, scene structure recovery from the camera motion, dense surface estimation and scene surface reconstruction.

Feature extraction and matching serve as the starting point for reconstruction, focusing on accurately detecting stable feature matching point pairs in images from different angles [7]. Image feature selection usually selects the gray value of the image pixels, but in the landfill image, only the gray discrimination value cannot provide enough information, so we will select the areas with some differences on the image but some duplication between the images for feature supplement. Various feature extraction algorithm will have its scope of application, usually in order to feature extraction and matching stage algorithm accuracy and efficiency, in some complex scenarios can be combined with a variety of algorithms (such as lack of texture background can use ORB + GMS + RANSAC three combination of algorithm), to ensure the reconstruction results accurate error reduction.

Multi-view geometric constraint calculation refers to the use of polar geometry into the basic matrix model parameter estimation, in Euclidean geometry, its principle is like one and like two space point matching must be located in the point and two light center in the plane and like plane intersection, this method effectively reduce the search space from two-dimensional to one dimensional. In other words, it can be determined by the above method a point in a view in other views where the pole line and the corresponding matching point pixel coordinates, all the images between the pole line constraints, as long as any two pictures have a certain number of characteristic points in and above can calculate the relative position between the two pictures, and calculate to restore these matching points in the three-dimensional coordinates of real scenes.

Restore scene structure from the camera motion is an uncalibrated set of images as input, with feature detection and description algorithm to obtain the matching feature points in the same scene, through multi-view geometric constraint estimation, the projective reconstruction camera reference and camera position and direction, with beam method translation algorithm reduction error, finally measure the output of the process is sparse three-dimensional scene structure point cloud.

Although the sparse point clouds already have certain information, and we need to conduct the dense surface reconstruction in order to display more abundant detailed information, the dense surface reconstruction work for complex scenes is very difficult. According to the complexity of the objects in the scene, the dense surface reconstruction can be summarized into the following four categories: depth map method, voxel method, mesh method, and face sheet method. First of all, the depth graph method is often used in the reconstruction of small objects because of the complex acquisition of the depth estimation algorithm, and its real-time performance is poor. Vvoxel method is to imitate point cloud to build discrete small squares, which requires high hardware equipment and cannot guarantee clear results with high resolution. The grid method reoptimizes the object contour based on the model initialization, which is not suitable for the reconstruction of irregular objects in the scene. The patch method is to use the gray similarity to draw the reconstruction scene in the form of a set of small pieces. Compared with the previous methods, it is more suitable for the complex scene reconstruction on a large scale, and the results are closer to the real object.

Finally the reconstruction model is exported in a point cloud format, using the boundary function to data boundary, to as far as possible to extract the boundary point can restore the scanning object contour, and then divide the bottom side area into multiple cubes, according to the upper boundary z axis information (the height) of the volume of the cube, finally sum the model volume, the method is similar to the integral.

To sum up, image-based scene reconstruction is placed by many scholars and widely carried out in different fields such as heap stability monitoring and storage capacity expansion, however, it saves the memory of the equipment, including the time saving of optimization algorithm and accurate reconstruction results. Late research should be to build advanced and accurate 3D reconstruction methods of solid waste landfill and system, can learn from advanced reconstruction methods in other fields, combined with the environmental factors around the landfill and its structure characteristics, clear 3D reconstruction hardware selection and method selection, on the basis of further optimization study the applicability of different solid waste landfill.

4 STUDY ON 3D RECONSTRUCTION OF SOLID WASTE LANDFILL

4.1 Analysis of the actual situation

Monitoring of solid waste landfill sites includes monitoring of leachate leakage, groundwater quality monitoring and safety monitoring [8,9]. The surface information of the landfill is visualized through the 3D reconstruction technology, which helps the managers to get familiar with the operating conditions and conduct a more refined management of the incoming waste.

First, this method helps for accurate monitoring. Landfill operation surface information including black rain film cover, operation compaction, pile slope stability, settlement changes, etc., there may be not in time after operation to cover the rain into the landfill, the leachate in the HDPE film accumulation, landfill waste in leachate soaking time caused the overall slope sliding, bring safety risks. However, the full monitoring of landfill managers can effectively reduce the probability of risk occurrence and provide the guarantee of landfill operation [10].

Second, the estimated volume changes can be used to reflect the landfill volume. Due to the increase of daily garbage disposal capacity, some landfills are saturated in advance, while some landfills are underutilized. Therefore, we need to carry out orderly management and grasp the storage capacity of the landfill, and improve the utilization rate of the storage capacity. The volume estimation can not only make the landfill amount clear, prevent illegal transfer and dumping, but also grasp the landfill location, improve the whole process of waste supervision process, and provide data support for the reuse of valuable landfill resources in the future.

Finally, the combined waste traceability tag matches the waste attributes with the volume change region. Therefore, it can be judged whether there will be incompatible substances in the landfill materials, and add the garbage treatment and disposal planning factors to divide the landfill area reasonably, avoid the explosion of chemical reactions between the waste products, better supervise the landfill operation, and ensure the safe operation of the landfill site.

4.2 Results

The 3D reconstruction of landfills is in the exploratory stage, so this study only uses price-friendly single camera to verify. The experimental site was paved with black film cloth to simulate the actual state of the landfill. As shown in Fig. 1, the length is 40m and the width is 18m. After reconstructing, the measured length is 41m and the width is 17m, which is very close to the actual scene and restores the reality (as shown in Fig. 2), so the reconstructing method of monocular camera is feasible.

Figure 1. Site Diagram.

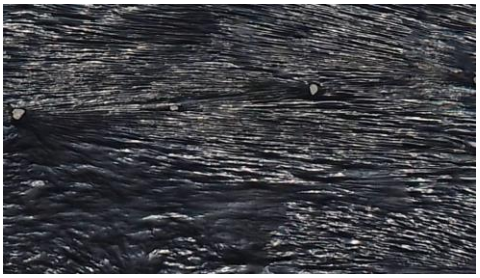

Figure 2. Reconstruction result with clear texture

5 CONCLISION

- The 3D reconstruction technology effectively realizes the transformation of the actual scene and the digital world, and also gradually tends to the large-scale scene reconstruction. In this study, we summarized the popular methods of 3D reconstruction of active and passive aspects, and analyzed the principles, advantages and disadvantages of active laser trigonometry, time of flight method and structural light method, passive monocular stereo vision, binocular stereo vision and multilocular vision, and applicable scenarios. The word “data” is plural, not singular.

- Combining the characteristics of the landfill and the actual requirements of landfill applicability analysis, screening out monocular camera multilocular vision technology suitable for landfill body, detail the reconstruction process and method selection, and clearly based on landfill 3D reconstruction is still in the exploration stage and points out the current problems and subsequent research difficulties, for future in-depth landfill 3D reconstruction research ideas.

- The reconstruction research of solid waste landfill can help to accurately monitor the landfill process, master the landfill information, identify the potential risks, do a good job in the guarantee and management of solid waste treatment and disposal, and effectively carry out harmless and accurate quantitative evaluation, and promote the fine and intelligent management of the landfill.

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