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Application of Slam Technology in Integrated Surveying and Mapping of Real Estate

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Abstract: SLAM (Real-time Positioning and Map Construction) technology has a good application in mobile mapping, relying on inertial navigation technology, three-dimensional model construction. The integrated surveying and mapping of real estate is often complicated with tasks, large coverage area, high technical requirements and time consuming. The application of SLAM technology has the advantages of high efficiency and high precision. It does not need to mark a large number of GPS signals of ground object points, and effectively solves the problem that the area obscured by aerial survey cannot be interpreted. Combined with the relevant requirements of rural real estate surveying and mapping, this paper conducts rural real estate surveying and mapping through 3D SLAM handheld 3D laser scanner, and discusses its value and adaptability in rural real estate surveying and mapping. SLAM (Simultaneous Localization and Mapping) Real-time positioning and map construction: it can move from an unknown location in an unknown environment, position itself according to the environmental characteristics and map in the process of moving, and obtain three-dimensional spatial data on the basis of its positioning to make an incremental map and complete the map construction. Rapid and accurate positioning can be realized in closed space, and it is widely used in underground space positioning and modeling [1]. This paper discusses the application of 3D SLAM technology in rural real estate integration project, through the measurement examples, analysis of the measurement accuracy and error, and compared with the traditional measurement method, reduce the complexity of measurement, make the working efficiency has a significant increase, its use in the rural real estate surveying and mapping has a certain value and adaptability.

1. Difficulties in Technical Means of Real Estate Integration Measurement at the Present Stage

Real estate integration is a very important work in the registration of real estate in our country, which lays a good foundation for the development of rural revitalization and the promotion of rural reform [2]. Confirmation, registration and certification of rural homestead and collective land for construction is an important measure to safeguard farmers' legitimate rights and interests and promote the harmony and stability of rural social order. It is also the basic content of establishing and implementing a unified registration system for immovable property.

Traditional surveying and mapping methods (total station and RTK) and operating methods (diagram, household, etc.) have some difficulties, such as high labor cost, no signal and imvisibility in densely built areas, large cumulative measurement errors, single results and other difficulties. ① Affected by the weather, most of the work needs to be carried out in the field, so when the weather such as rain and snow, it can not be carried out. ② The work efficiency is not high, whether it is in the field or the industry tasks are very heavy, resulting in high project costs and long cycle. There is no advantage when it comes to flat land, small area and densely built countryside. (3) When it comes to rural areas with scattered buildings and undulating terrain, total station and RTK measurement have certain advantages, but the results obtained by this measurement method are relatively simple and cannot meet the needs of diversified measurement [3].

At present, tilt photogrammetry technology is av ailable, which can improve the accuracy of data and the efficiency of operation to a certain extent. However, field operations with tilt photography technology need to lay out a large amount of phase-controlled points, a large amount of data, high requirements on hardware equipment for tilt 3D modeling, easy problems in space and space, high requirements for field operating environment, and mostly affected by weather factors. In addition, vegetation cover, building facades are easy to pull, concave and convex deformation caused by mapping errors, long data production cycle.

Existing mobile measurement systems based on vehicle-mounted platforms and unmanned aerial vehicle platforms rely on Global Navigation satellite systems (GNSS) and inertial navigation systems, and can only be used in outdoor open environment. When the rural housing is dense and the floor is high, the on-board system is easy to cause the loss of GPS signal, and the data accuracy cannot be guaranteed. Secondly, the road is narrow and the measuring vehicle is inconvenient to pass.

Although the UAV-borne radar does not have to worry about the loss of GPS signal, limited by multiple factors such as fixed laser scanning Angle, flight speed and relative altitude, there are some problems in the data acquisition results such as missing mining or too sparse point density to meet the requirements of mapping. Although airborne Lidar has high precision, it requires high professional skills of personnel. When the laser point cloud is placed in a large proportion, the object display is not intuitive due to the point density, and data processing by professionals is required. In the actual measurement of rural premises, the number of floors of the house can be changed according to the height of the house, and the attached columns of the house can be evaluated by multi-directional observation of other accessories. For example, terraces, colonnades, unsealed balconies, etc., can be evaluated by experience. If the house appendages cannot be distinguished from the main room, the field painting is adopted [4].

2. 3D SLAM Mobile Scanning Technology

SLAM technology has its own advantages in the acquisition of spatial data of rural premises. It does not need GPS signal and has strong adaptability to the working environment. It can move from an unknown position in an unknown environment and position itself according to the environmental characteristics and map in the process of moving. At the same time, on the basis of self-positioning, three-dimensional spatial data is acquired to make incremental maps and complete map construction [5]. The measurement principle of SLAM technology is shown in the figure 1.

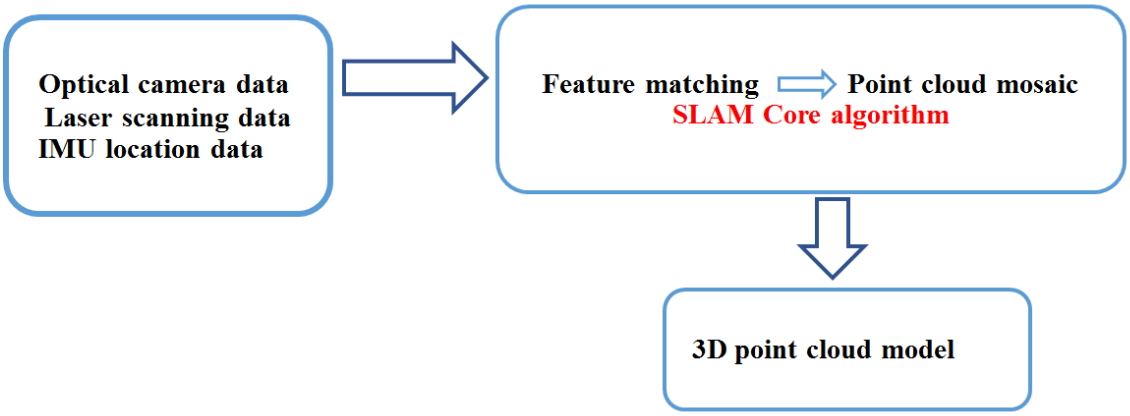

Figure 1: Measurement principle of SLAM technology

SLAM was proposed and defined by Smith in 1986. Synchronous positioning and map construction, which was first proposed in the field of robotics, refers to the robot starting from the unknown environment, positioning its own position and attitude through repeated observed environmental features in the process of movement, and then building an incremental map of the surrounding environment according to its own position, so as to achieve the purpose of simultaneous positioning and map construction [6]. Since Smith proposed and defined the concept of SLAM in 1986, it has come a long way since it was proposed and developed More than 30 years of history. Development from early sonar, and later 2D / 3D Lidar, to monocular, binocular, RGBD, TOF and other cameras, as well as the fusion of sensors such as IMU; The algorithm of SLAM has also changed from the original filter based square method (EKF, PF, etc.) to the optimization based method. In recent years, the SLAM algorithm based on Lidar and vision sensor has been widely applied, and the technical framework has evolved from the single thread at the beginning to multi-thread [7].

At present, the common mobile measurement system is usually based on the vehicle or unmanned aerial vehicle and other motion carrier measurement system, need to absolutely rely on the global navigation satellite system (GNSS) and inertial navigation system, can only be applicable to outdoor environment scanning, unable to meet the closed environment without GPS satellite signal continuous operation. Rack-mounted 3D laser scanner does not require GPS assistance for positioning, and can be used for indoor and outdoor environment scanning[8]. However, a large number of stations need to be changed in complex Spaces, and then cloud stitching of test stations is carried out. The collection and post-processing efficiency is very low. However, SLAM scanner technology has a good application in closed space for mobile scanning. It does not rely on GPS signals to assist positioning, and can conduct continuous mobile scanning of indoor and outdoor environments. Therefore, the application of SLAM technology in the field of mapping reduces the complexity of measurement and does not need to mark a large number of ground object points. It is suitable for indoor and outdoor scenes, and has a broad prospect for solving the location of complex closed space and scene reconstruction mapping at the present stage[9].

Although the on-board radar of UAV does not have to worry about the loss of GPS signal, the GeoSLAM ZEB-HORIZON scanner is currently a cost-effective scanner limited by multiple factors such as fixed laser scanning Angle, flight speed and relative altitude. It is also the device with the longest range, highest point density, and most platform modes in the GeoSLAM product line[10].

The mobile measurement system of SLAM technology plays a role in a number of mapping fields. The specific performance is as follows: (1) The speed of data acquisition is extremely fast, and the required point cloud data can be quickly obtained with high data accuracy. (2) Non-contact scanning, and has strong adaptability to the acquisition environment, can be scanned in the all-black environment. (3) The point cloud preprocessing in the internal industry has a high degree of automation, without manual intervention, and a large number of point cloud data can be obtained in a short time. (4) The operation is simple and easy to learn, there is no need to change stations, continuous collection, consistency, can realize indoor and outdoor integration scanning operation[11].

3. Engineering Cases

3.1 Survey Area Overview and Survey Process

The measuring area xx village is located between 108°22 '~109°46' east longitude and 33°46 '~34°1' north latitude. It is an administrative village under the jurisdiction of Xi 'an, Shaanxi Province. The whole terrain is mainly alluvial plain. The houses in this area follow the traditional architectural features of Guanzhong area. The villages are neatly distributed and the layout of houses is mostly rectangular.

The whole-house measurement process of GeoSLAM is shown as follows Figure 2:

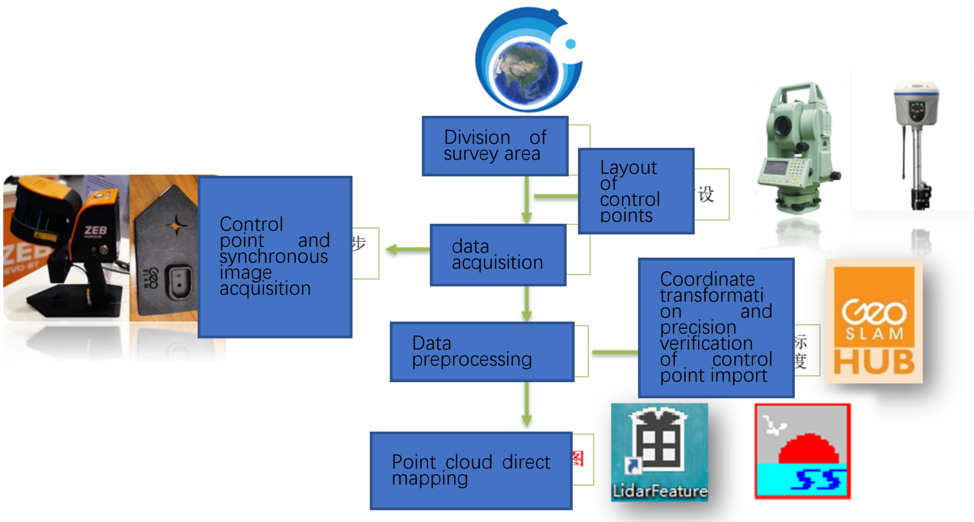

Figure 2: GeoSLAM one-premises measurement process

3.2 Field Data Collection

The GeoSLAM handheld mobile 3D laser scanner, with a laser head weighing 1.3Kg, is portable and capable of 360-degree panoramic scanning. It can scan for 4 hours with a single battery, and can work in the narrow area without GPS signals to collect the data required by the project[12].

Site survey. Before the formal operation, the field survey was carried out, and the analysis of azimuthing trend, inflection point position and intersection position was carried out for the area to be measured[13]. The data collection scheme and matters needing attention were planned and designed. In order to ensure the accuracy of point cloud registration, as many closed routes were designed as possible, and the design scheme was reasonable and efficient.

Layout of control points. Using RTK, there is no need to see through each point, and the characteristics of the network structure are not taken into account. The control points are evenly distributed. Usually, each test section has an average of 3-5 control points, and the control points cover the whole test area. During the measurement, three times of initial measurement should be carried out for each point, and the time of each measurement should not be less than 10 seconds. Moreover, the result of two measurements should not be larger than 3 cm, and the height difference should not be larger than 3 cm. The final result should be the average value of the plane and the elevation, as shown in Figure 3 and Table 1.

Figure 3: Schematic diagram of image control points

Table 1: Results of image control points

Results of Image Control Points in xx Village				
Order number	Point number	North latitude x	East longitude y	Altitude z
1	K1	**82980.9880	**561911.9514	367.9295
2	K2	**82924.2466	**561808.7496	368.2769
3	K3	**82904.3061	**561851.8664	376.9467
4	K4	**82817.9045	**561907.9504	366.9598
5	K5	**82814.3492	**561810.1826	367.3895
6	K6	**82694.3498	**562001.5608	366.7773
7	K7	**82726.9981	**561920.9509	366.6216
8	K8	**82727.3283	**561818.1960	366.8907
9	K9	**82636.8868	**561905.1834	367.8124
10	K10	**82635.9318	**561812.7993	367.7613

Data acquisition. Start the machine on the flat ground, and after the initialization with the instrument, conduct 3D panoramic scanning according to the planned scanning path. The scanning should achieve full coverage without omissions. Usually, the completion time of a path planning collection should be controlled within 25 minutes, and the path is a closed scanning path. In the process of scanning and walking, the main tester scanned more closed paths to control the accumulation of errors and improve the accuracy of point cloud registration. A total of 4 test segments and 10 control points were collected in this test, and the scanning time was more than 70 minutes. Each survey section can collect about 30-50 houses.

3.3 Internal Data Processing

For the survey of rural real estate title by GeoSLAM scanner, the field data collected can only be used as original data, which needs to be processed by subsequent data processing software. After the coarse errors are screened, the pre-processing software is applied

Calculate in the hub, calculate the moving trajectory of SLAM through the relative position, and then calculate the point cloud data around the moving trajectory. The time required to solve data is related to the scanning time, which is generally 1-3 times longer. 3D point cloud data is directly generated, as shown in the figure 4:

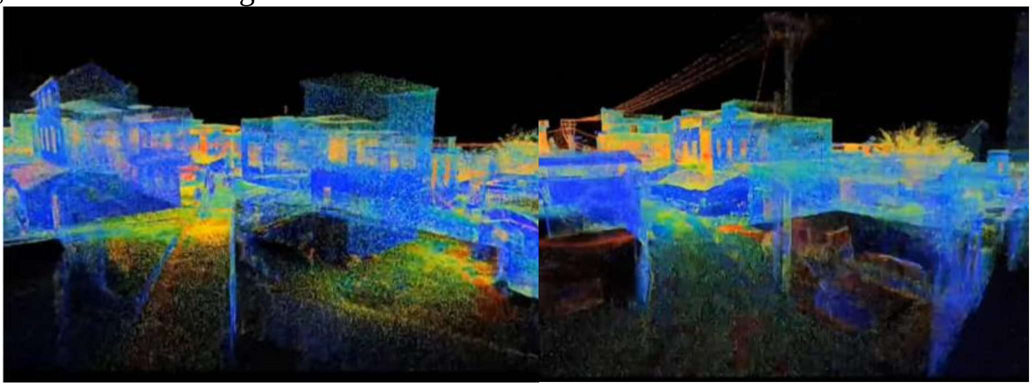

Figure 4: Solving the SLAM trajectory

The completed point cloud data can directly generate a 3D model, so as to obtain the overall 3D model effect of the point cloud in the test area, under QuickTerrain

In Modeler software, we can directly view the spatial position of the building, interpret the building structure, floor and indoor and outdoor information, and measure the side length and area of the building, as shown in the figure 5.

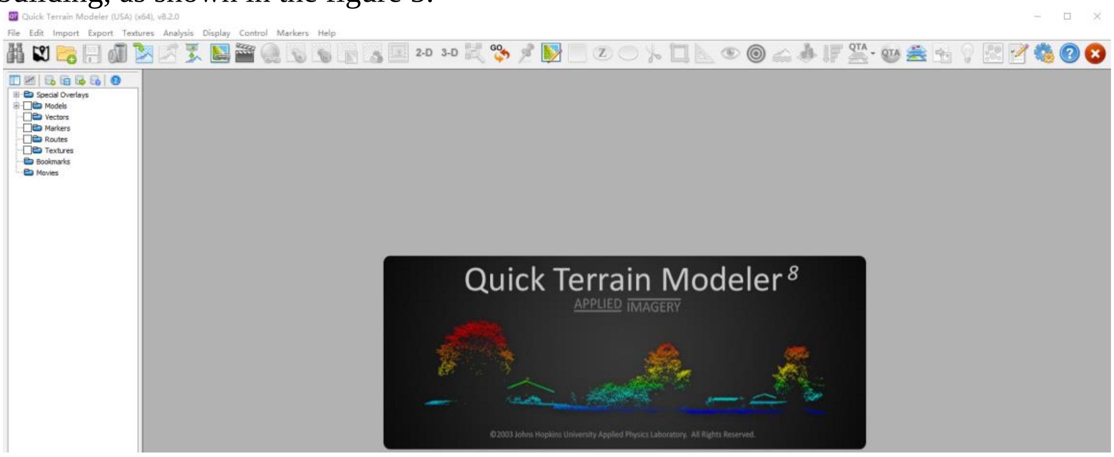

Figure 5: Point cloud data view

In the test area, one person and one machine can automatically preprocess four sections of data and convert point cloud geographic coordinates of each test section. The accuracy of geographic coordinate conversion is better than 5cm. Compared with field data collection, the time ratio of internal data preprocessing is

The four sections of point cloud data registered by geographic coordinates were respectively output in the general las data format, and directly imported into the Lidarfeature software for quick point cloud mapping, and the digital line map of the test area was made, as shown in the figure 6.

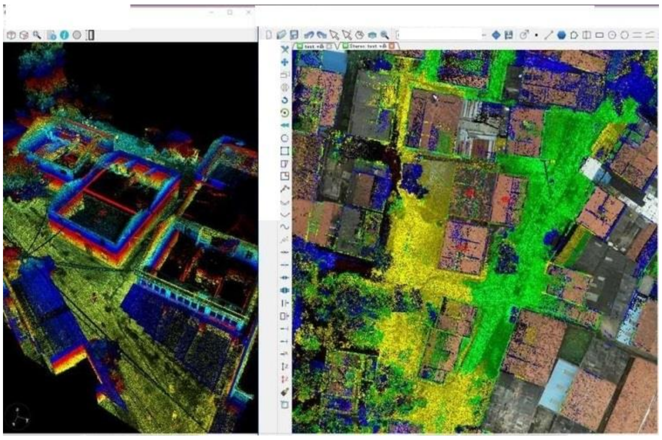

Figure 6: Point cloud mapping

3.4 Precision Analysis

In this test, the measurement point coordinates of the total station were compared with the scanning data set of GeoSLAM. A total of 10 total stations were selected to measure scatter points as the accuracy of this verification. The comparison found that the maximum error was 4.1cm and the medium error was 2.87cm, which was superior to the standard requirements and met the accuracy requirements of the integration of rural housing, and could be used as the results. The precision pairs are shown in Table 2.

Table 2: Precision comparison table of boundary point coordinate data

Order number	Original X(m)	Original Y(m)	Inspect X(m)	Inspect Y(m)	△X (mm)	△Y (mm)
1	3870284.790	542329.289	3870284.810	542329.300	-20.0	-11.0
2	3870285.208	542326.342	3870285.239	542326.353	-31.0	-11.0
3	3870287.291	542312.394	3870287.323	542322.420	-32.0	-26.0
4	3870283.394	542269.111	3870283.402	542269.114	-8.0	-3.0
5	3870289.395	542298.499	3870289.399	542298.551	-4.1	-52.5
6	3870280.701	542293.612	3870290.729	542293.615	-28.0	-3.0
7	3870281.243	542290.031	3870291.257	542290.043	-14.0	-12.0
8	3870281.430	542284.632	3870291.456	542284.660	-26.0	-28.0
9	3870282.979	542274.420	3870292.944	542274.461	35.0	-41.0
10	3870283.517	542270.736	3870293.525	542270.741	-8.0	-5.0

The data of various types of housing areas obtained by GeoSLAM handheld 3D laser scanner are compared with those obtained by spot check, as shown in Table 3:

Table 3: Area data comparison table

Households number	house type	Point cloud area/ m^2	Detection area/ m^2	D-value/ m^2	Tolerance/ m^2
18	Brick house	101.15	100.98	0.18	0.81
23	Shack	76.94	76.42	0.52	0.62
30	Brick house	177.45	176.92	0.53	1.33
46	Wall	24.42	24.49	0.07	0.15
59	Brick house	139.59	139.87	0.53	1.33

The one building project requires accurate measurement of the area of all kinds of houses so as to make family maps and household maps, etc. Through the comparison of randomly checked brick houses, shed houses and walls, the accuracy of the area is within the required range, and the poor building area meets the accuracy limit of the house area in CJJ/T 8-2011 Real Estate Measurement Code [14]. We found out by comparison GeoSLAM scan data is better than the standard requirements, meet the requirements of the precision of the integration of rural housing, and can be used as the final result.

3.5 Operation Efficiency Analysis

In order to analyze the accuracy difference between GeoSLAM and traditional total station measurement technology, the time spent in each link of the experiment was calculated. In rural residential areas with dense houses and trees, the field collection efficiency was increased by 6 times by using 3DSLAM three-dimensional laser scanning technology [15]. A single machine can quickly complete the field data acquisition. Compared with the traditional total station measurement method, 3DSLAM technology can improve the working efficiency to a large extent, which is mainly reflected in the data acquisition of real estate field. However, the author also found that compared with the traditional measurement method, 3DSLAM acquisition is a little heavy in problem solving due to the lack of understanding of the field situation.

4. Conclusion

With the popularization of SLAM measurement technology, more and more people have felt the big difference between it and the traditional measurement instrument. GeoSLAM Horizon scanner can generate 3D point cloud data in a short time, and point cloud data can be directly drawn vector map. Compared with the traditional measurement method, this operation method not only saves time, improves the working efficiency, but also greatly reduces the input of manpower and material resources. More importantly, the accuracy of mapping is also guaranteed to a large extent. At present, there are many options for 3D laser scanner, but for this small range, high density of real estate integration measurement, handheld scanner operation mode is flexible, only two people can complete the field scanning work, the operation time is controllable. According to comprehensive analysis, the mapping efficiency of GeoSLAM Horizon measurement technology is 6 times that of total station and RTK measurement mode, and 2 times that of aerial tilt photogrammetry mode. It saves project input cost, and the result data is reliable. It is feasible to use GeoSLAM multi-platform mobile 3D scanning system to complete the integrated measurement of real estate.

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