SLAM100

Fieldwork Guidebook

Working Precaution

1. The gimbal between the scanner body and the laser head is a precision mechanism, please handle it with care and avoid bump!!!
2. After use, please store it in the carry box as soon as possible.
3. The dark part of the laser head is the emission area, so please avoid friction and collision between this module and hard objects.
4. When taking the equipment out from the box, please use two hands with one hand holding the handle and the other holding the laser but don't tough the scan area, and do not drag it out forcefully.
5. When installing a memory card, please make sure the memory card is unlocked and there is enough space for acquisition.
6. Please make the electrodes right when mounting the batteries, and then tighten the screw on the handle.
7. The battery should be placed in the carrying box during transportation to avoid contact with liquids or bumps with hard objects.
8. Please pay attention to the direction of the positive and negative electrodes when charging and use.
9. Be careful not to damage the battery from falling after flipping two clips aside to take them out.
10. During the data collection process, please keep the scanner in front of your body, in the same direction as you are walking, with the laser head facing upwards and don't disturb its rotating with touch or other movements.
11. There are three groups of camera lenses on the side of the fuselage, which should avoid friction or collision with hard objects.
12. Power on
    - 12.1.The light will be solid green after long-press for about 3s and after about 40s, the laser will start rotating and standby.
    - 12.2.The light will flash after a short-press which means the device is start to collect data. Please stay still for about 10s before moving forward so SLAM100 can acquire environmental data around the start point.
    - 12.3.When finishing the acquisition, short press the button so the equipment stops working and the green light will be on.
    - 12.4.To power off the device, the operator needs to long press for 3s till the green light turns blue and the laser stops rotating.
    - 12.5.Please pay attention to the level of the battery. The yellow light will be on when the battery is low, so please charge it after the operation.
13. Please read the user manual and fieldwork guidebook carefully before use.

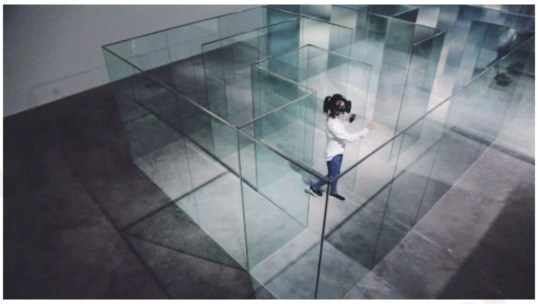
Fieldwork Guide

1. Scenario Applicability

Since SLAM100 can work without GNSS signal, it can be used in under/over-ground and indoor and outdoor scenarios, such as underground garages, narrow passages between tall buildings, etc.; Since LiDAR can work without light, so the use of Lidar-based SLAM100 is not affected by light, as a result, SLAM100 can work in Karst Cave, mine tunnels, air raid shelters and other scenes.

Because LiDAR can be affected by refraction and reflection, so the laser-based SLAM100 are not suitable in scenes with a lot of glasses or mirrors, such as mirror mazes, transparent buildings, etc.

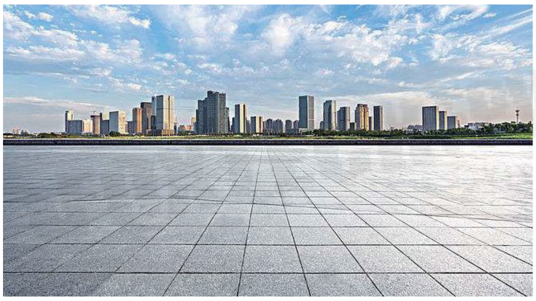
Since laser-based SLAM100 needs to do matching relying on the pre-acquired 3D point cloud data, so the accuracy cannot be guaranteed if the map formed by the data have large area with similar structure, such as long straight corridors with no geometric differences or squares without any geometric structure, etc.



Mirror Maze

Transparent Building

Straight Long Corridor



Wide Square

Fig1.1 Scenarios in which SLAM100 has low applicability

2. Division of Survey Area

In use of SLAM100, in principle, as long as it has enough power, storage space, and there are enough close-loops in the acquisition process, the acquisition time is not limited by the duration. However, if the area to be collected is very large, it is suggested to divide it in to blocks to collect data and there should be enough overlapping areas between each block, which is helpful for the software doing calculation.

Fig2.1 is a map of a campus divided into different survey areas. Each color represents an independent operation. There should be overlapping areas between operations as much as possible and it is recommended that the overlapping area should not be less than 1/4 of the survey area.

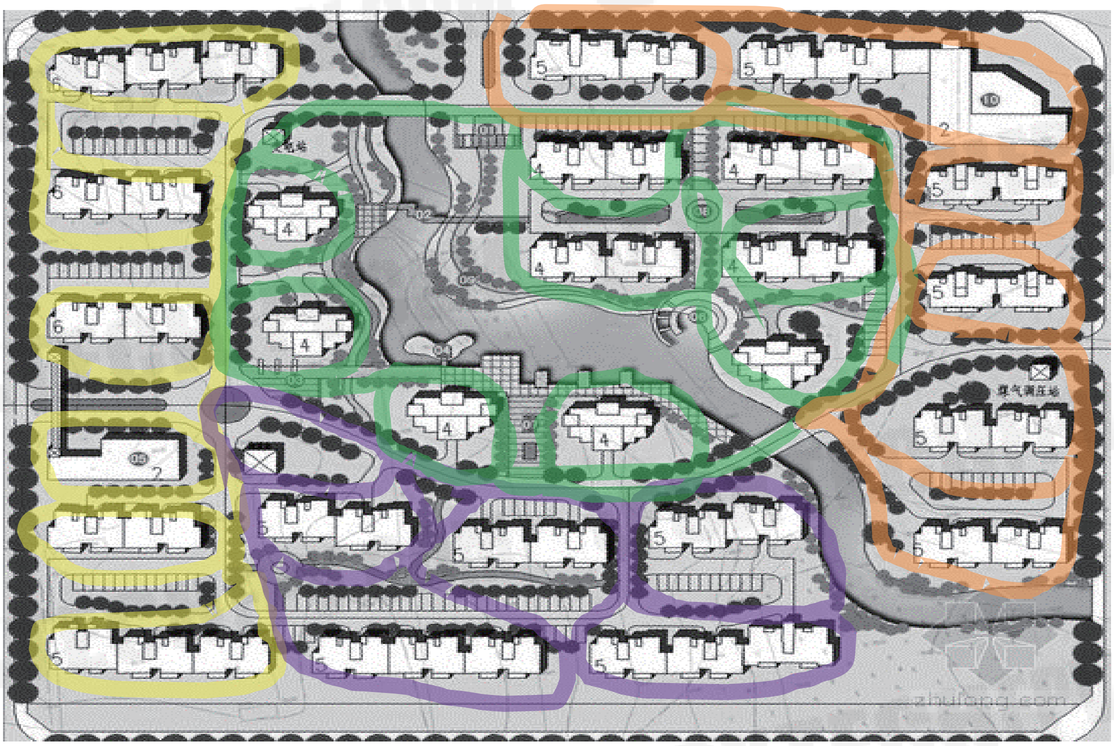


Fig2.1 Schematic diagram of the division of the survey area

3.Route Planning

SLAM100 is a handheld laser scanner, which needs to be hand-held for data acquisition, so it doesn’t support automatic route planning. Before the operation, following contents can be referred to to plan the survey route. Reasonable route planning can effectively guarantee the overall accuracy of the data.

3.1.Close-loop Route

In order to reduce accumulated error during the acquisition, it is necessary to plan closed loops as much as possible, i. e. collect data of the same area in different time periods. The key of close-loop is to have overlapping regions with length about 5~10m. The overlapping areas can be coincident in the same direction or in the opposite direction.

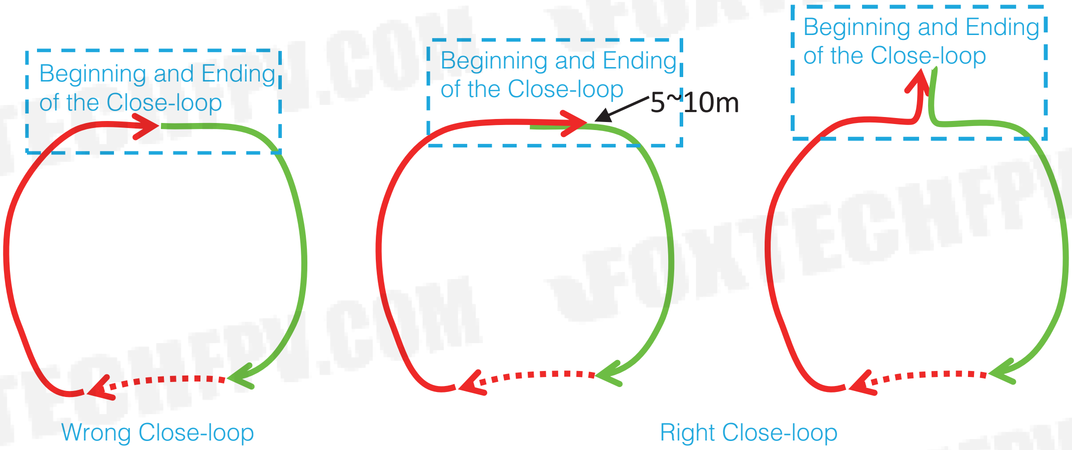


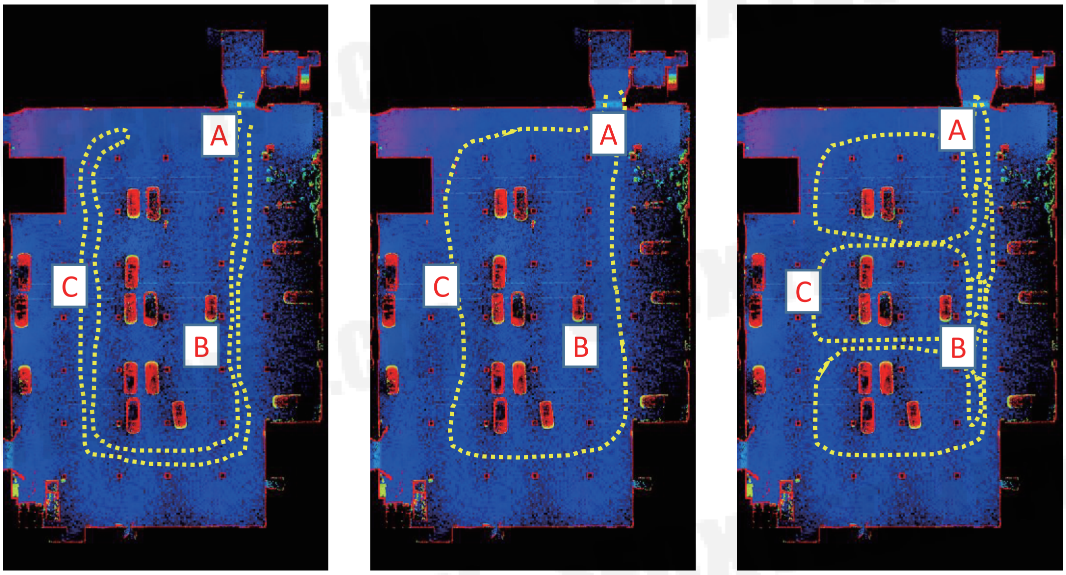
Fig3.1.1 Different Planning of the Close-loop

3.2.Closed-loop in Single-story Buildings

The error will accumulate as the distance increases. For single-story building, there should be as many O-shaped close-loops as possible instead of linear close-loops, which may control the error to the minimum range.

Why are multiple small-O-shaped close-loops more beneficial for global accuracy? Fig3.2.1 are three route plannings of the same area. Measure the shortest distance between two points and estimate the corresponding error, assuming that every 100m distance will form a relative error of 1cm.

	Distance between A-C	Relative Error of A-C	Distance between B-C	Relative Error of B-C
L-shape Route	500m	5cm	250m	2.5cm
Single-O-shape Route	120m	1.2cm	250m	2.5cm
Multi-O-shape Route	120m	1.2cm	75m	0.75cm



Round-trip Route (Less Effective)　Single-O-shape Close-loop (Better Effective)　Multi-O-shape Close-loop (Most Effective)

Fig3.2.1 Route Planning in Single-story Building

3.3.Close-loop in Multi-story Buildings

In the measurement of multi-story buildings, besides close-loop as many as possible in each floor, it is also necessary to plan the close-loop between the floors. If possible, the close-loop should begin and end from the stairs on both sides.

4.Working Distance

The laser ranging range of SLAM100 is 0.5m~120m.

4.1.Minimum Working Distance: point cloud data cannot be obtained within 0.5m of the laser, so please walking in the middle area of the working environment as much as possible to avoid missing data of front and two sides in small space.

4.2.The Farthest Working Distance: The measurement capability of the laser is about 120m when the reflectivity is higher than 60%. Since SLAM algorithm requires dense point clouds for calculating, although the data can be obtained at the farthest distance, its density cannot be used by the SLAM algorithm to calculate. When collecting data on the ground, please keep the object within 50m.

5.Handheld Method

When collecting data in a wide space(such as underground garage, residential area, park, indoor, etc.), please hold the device as shows in fig5.1, to collect point cloud and optical image synchronously.

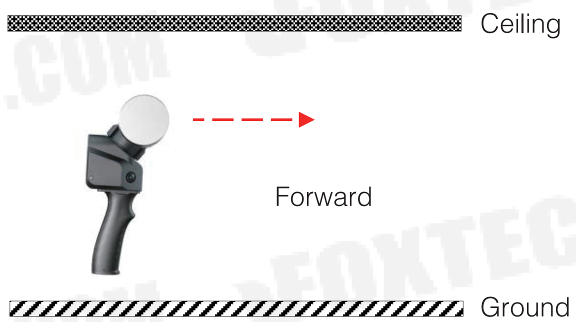


Fig5.1 Handheld Method

Before collecting data in places which is relatively close(such as underground air raid shelters, tunnels, sewage pipes, etc.), the operator can hold the SLAM100 in normal position for about 30s, and then slowly change to the horizontal place (Fig5.2) to obtain more uniform and comprehensive 3D data. But please do not use this method when collecting texture information.

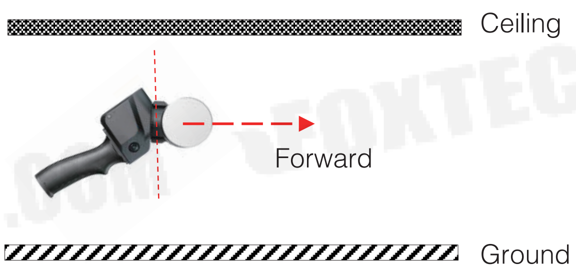
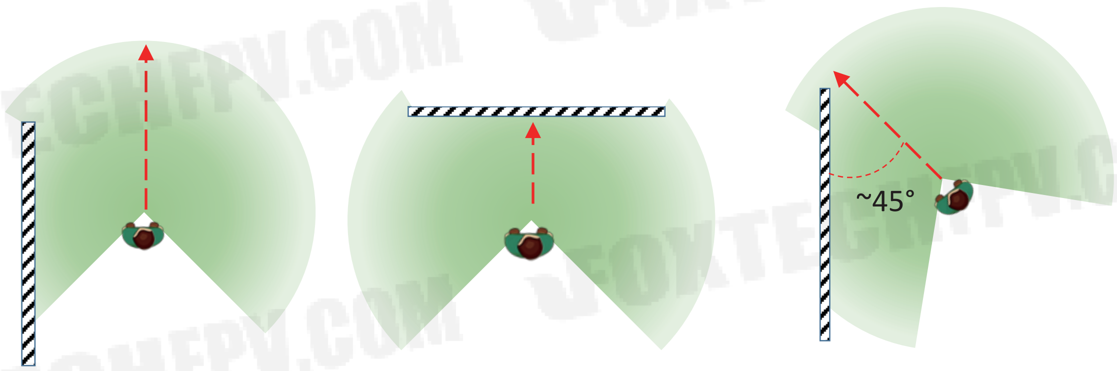


Fig5.2 Horizontally Hold in Long Narrow Space

When using SLAM100 handheld, it is necessary to keep geometric features within 50m in front of the device as much as possible to help matching and improve the accuracy of the SLAM algorithm. If the geometric features are only on one side in the environment, it may lead to errors in accumulation and the data accuracy cannot be guaranteed. In this case, the operator can hold SLAM100 with an angle(about 45°) against the geometric feature for data collection.



Geometric Features Only On One Side | Geometric Features at Front | Form an Angle With The Geometric Features

Top View of the position with the Geometric Features

Residential Area:
1)If there are buildings on both sides and at front, the operator can hold the device in normal position and go straight, and the data of the left, front and right buildings can be collected at the same time for matching;
2)If there are buildings on the left of the device but no building on the right or at front, then please hold the device with an angle about 45°with the building and walk along with the building. The device will focus on collecting buildings on the left in this scenario.

6.Scene Switching

The basic logic of SLAM algorithm is to match the 3D point cloud of each frame with the historical frames to calculate the current position and attitude. As a result, it is necessary to ensure that the current frame and the point cloud of the historical frame have enough overlapping data, which means the operator needs to collect enough links when switching scenes in some special spaces to tell SLAM that this two scenes are in the same coordinate system. Such as two-room switching, indoor/outdoor switch, corner transitions, etc.
Here are a few common-scene switches and the precautions for data collecting. Other scenarios can be learned from those examples.

6.1.Two-room Switch

When collecting indoor 3D data, the room scene is often switched. Before starting the acquisition, all the doors should be opened as much as possible. If it cannot be opened in advance, when passes the door, the operator should open the door with his back to avoid the continuously changing point cloud of the door due to its position changing interferes with the matching of the point cloud.

When passing through a door, try to avoid going directly from one room to another, especially if the door is small. Because sudden space switching may cause the 3D data of two rooms to be unable to connect; the correct approach should be to collect as much data as possible of two rooms at the same time when the operator standing in the middle of one of the room, to help matching two rooms(for example, a side stand at the door).

When passing through the door, please pay attention to the distance between the door and the wall to the laser due to the minimum measurement distance of the laser, which will affect the calculation.

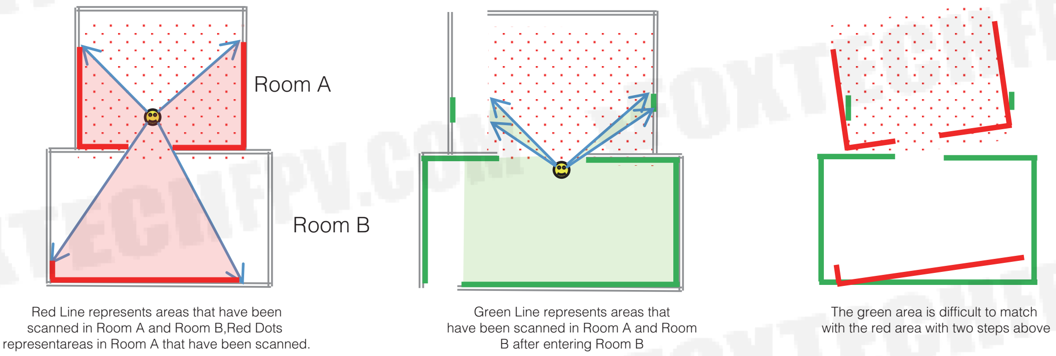


Fig6.1.1 Move Directly From Room A to Room B(Not Recommend)

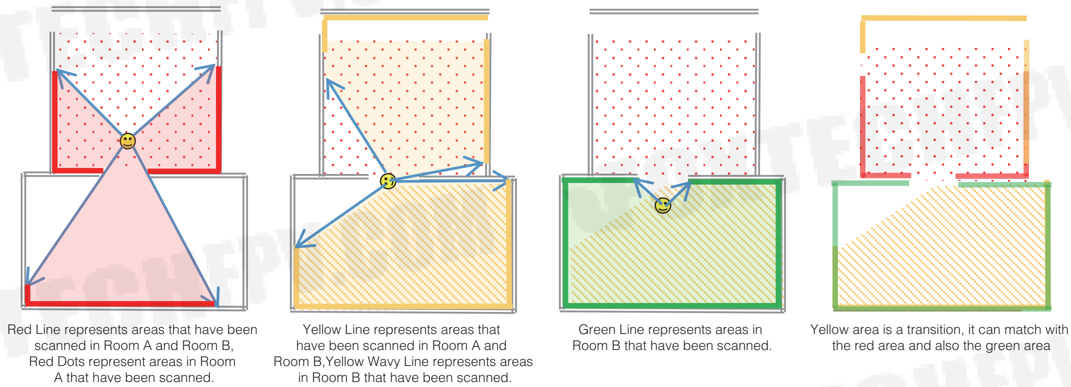


Fig6.1.2 Scan the room at the door before

6.2.Indoor/outdoor Switch

The transition between indoors and outdoors is mainly aimed at the scenes with no geometric features outdoors, which needs special attention, such as going into an small empty square. Similar to the transition between two rooms, if you go out directly, the indoor and outdoor data may not be perfectly matched due to the lack of link points.

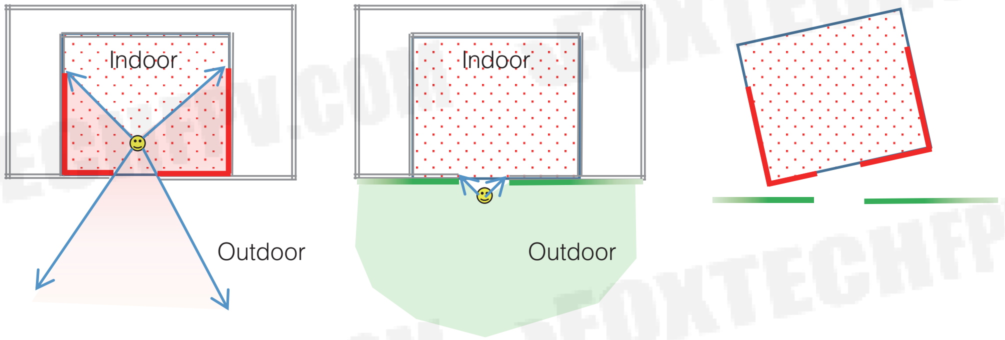


Fig6.2.1 Going Out Directly(Not Recommend)

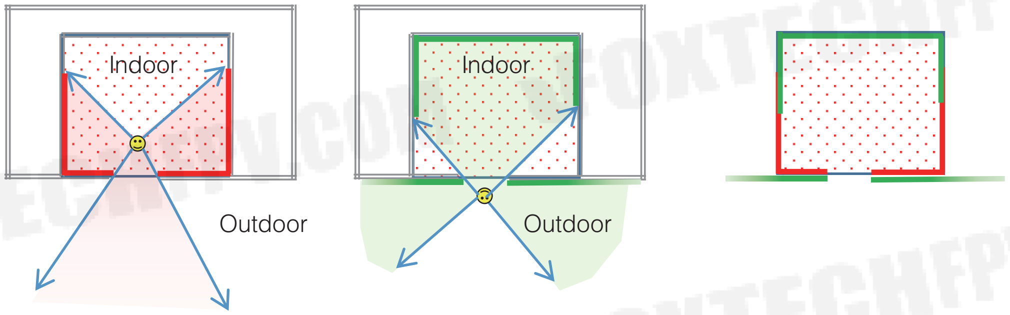


Figure6.2.2 Walk backward from indoor to outdoor, adding overlap areas(Recommend)

7.Control Point

There are two ways to collect control point. One is to directly use the control point collection module on SLAM100 for collection, and the position information of the control point is obtained during the data collection process; the other is to manually select control points from the output data, using post-processing. The comparison of two methods is as follows.

	Control point collection module on SLAM100	Select when post-processing
Processing Mode	Rigid Transformation/SLAM Algorithm	Rigid Transformation
Setting position	On the ground	Unlimited
Functions	Coordinate conversion, precision constraints, data stitching	Coordinate conversion, data stitching
Algorithm Support	SLAM100 software	Third party software
Collect Method	Automatic	Manual

7.1.Control Point Setting

Using control points, the operator can obtain absolute coordinates, carry on SLAM matching control, and data stitching. For different applications, the setting methods and requirements are slightly different.

7.1.1.Get Absolute Coordinates

To obtain the absolute coordinates of the survey zone, the control points should be evenly distributed and no less than 3. Theoretically, the more control points are, the more accurate the result will be.

7.1.2.SLAM Matching Control

As to SLAM matching control, the control points are mainly used to correct the drift data in the SLAM algorithm matching, and the absolute position is added for error clearing and position control. There should be no less than 3 control points, distributed in areas that are prone to drift (such as intersection areas when scene switching, areas with weak environmental geometry features, long straight corridors or tunnels, etc.). When used for SLAM matching control, it is recommended to set control points in area with strong texture every 100m, and set more in area with weak texture.

7.1.3.Data Stitching

When dividing survey area, the common control points can be used for data stitching. It is recommended to set the control points in the middle block, so that the whole survey area can be connected based on the middle survey area; if it is a strip type survey area , the control points are distributed in the overlapping area of both ends. Each overlapping area requires 3-4 control points, as shown in Fig 7.1.1.

Fig7.1.1 Control Point setting for Data Stitching

7.2.Control Point Collection

Please refer to the product manual for control point collection.

8.Additional Considerations

8.1.Walking Speed

Data collection is carried out at normal or slower walking speed in conventional areas. In narrow spaces, such as karst caves, stairs, and tunnels, the turning speed should be as slow as possible, and the speed should be slower when switching scenes, and please ensure that there are as much space as possible in front of the nose.

8.2.Moving Objects Avoidance

SLAM matching needs to match static data, so please don't face toward scene with lots of moving objects or people as far as possible. If a large range of the collected data is moving objects, when the matching is performed based on the moving object, it will cause the displacement of the static objects. When encountering such a situation, try to avoid it as much as possible. When it cannot be avoided, stop walking until the moving object leaves. Here are some situations needed to be avoided.

8.2.1.Avoid Facing Moving Crowds

During data collection, it is necessary to avoid the entourage in front of the operator, who should walk behind the operator or not follow; avoid data collection in crowd.

8.2.2.Avoid Facing Large Moving Objects

When collecting data from an open-pit mine, avoid mining trucks driving at a close distance (within 10m) ahead; avoid collecting data near large vehicles such as buses and passenger cars.