

Multi-return Firmware for Livox LiDAR

Document Release History		
Date	Release	Change Description
2019/2/25	V1.0.0	First release

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1. Background

The footprint of the laser beam increases as it gets farther from the LiDAR sensor. This is known as the beam divergence. When the entire beam hits an object, only one single return will be reported. However, in some cases, the laser beam may also hit multiple objects and thus produce multiple returns. Our multi-return firmware is designed to handle such issues. As shown in figure 1, in aerial LiDAR surveys, the last return is used to identify the ground. The other returns come from the tree as the laser beam traverses through all the tree branches. Therefore, the multi-return firmware is more suitable for forestry applications where the user needs to find the height of the trees.

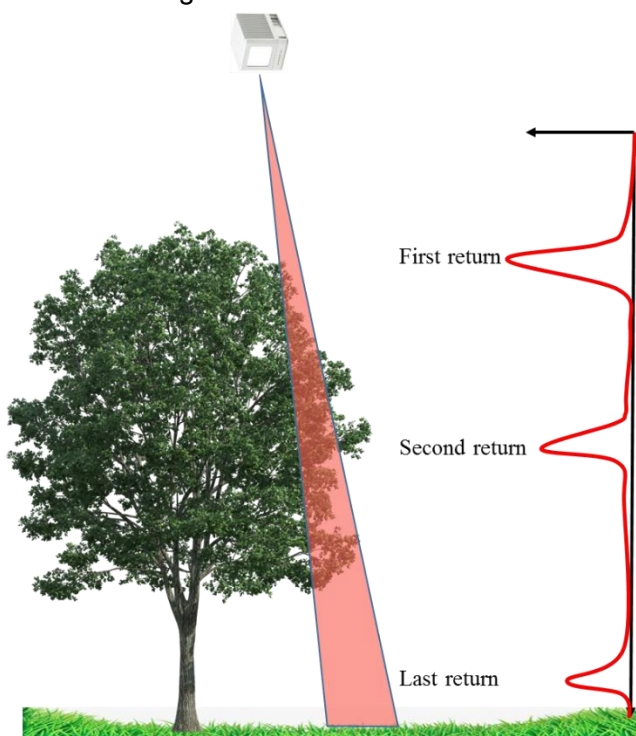


Figure 1

Another example is shown in figure 2, where the laser beam hits the wall through two pieces of glass. In this instance, a single laser firing results in 3 returns.

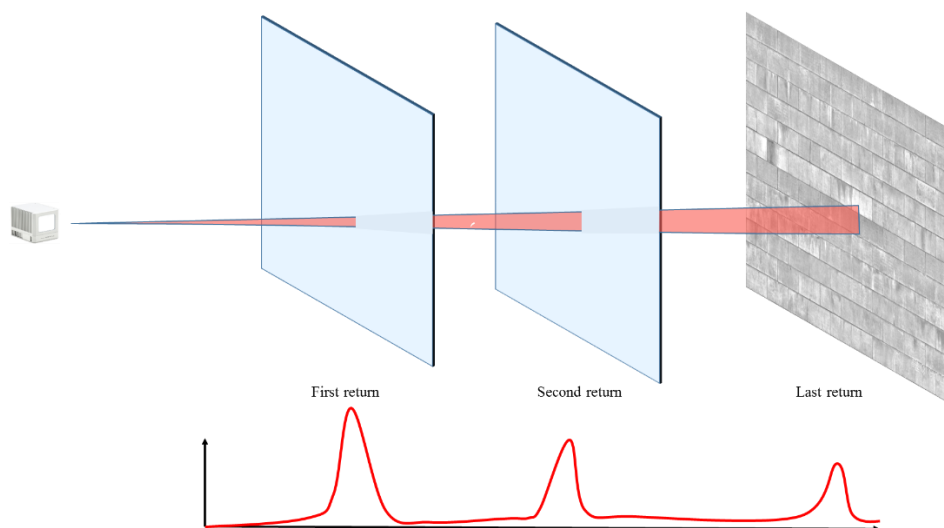


Figure 2

2. Firmware Info

Double Return Version:

Name	LIVOX_MID_FW_03.03.0001.bin
Version	v03.03.0001
Compatible Models	Mid-40/Mid-100
MD5	424E021858A2521D200FE6D2A422F90A

Triple Return Version:

Name	LIVOX_MID_FW_03.03.0002.bin
Version	v03.03.0002
Compatible Models	Mid-40/Mid-100
MD5	E7B618CE4CC5349F5F0090638F7B04B6

3. Characteristics

Due to communication bandwidth limitations, the sampling frequency of multi-return firmware is different from normal firmware shown as below:

Firmware	Normal Version	Double Return Version	Triple Return Version
Sampling Frequency	100KHz	100KHz	60KHz
Point Frequency	100KHz	200KHz	180KHz

The packet format of point cloud data of multi-return firmware is different from normal firmware. In order to distinguish the depth between different return calculations, the reflectivity of the first return is the reflectivity value of the object itself, and the reflectivity

value of the second return is set to a fixed value of 200 (its color in the Livox Viewer is Orange), the reflectivity value of the third return is set to a fixed value of 250 (its color in the Livox Viewer is Red). The header of point cloud data packet (first 11 bytes of the packet) is the same as normal firmware (refer to the page 9 and 10 of [Livox SDK Communication Protocol](#)).

Double Return Point Cloud Data

Each packet contains 100 point cloud data, including the first return and the second return of 50 samples. If no multiple returns are detected, the corresponding point data will be set to 0.

Timestamp in header of point data packet indicating the time of the first point in the packet. The sampling frequency is 100k, so the time interval of each pulse is 10us. Point cloud data format is shown as below:

Point Num	Sample Sequence	Time	Reflectivity
1	1	T1	0~255
2		T1	fixed value:200
3	2	T1 + 10us	0~255
4		T1 + 10us	fixed value:200
...	
97	49	T1 + 490us	0~255
98		T1 + 490us	fixed value:200
99	50	T1 + 500us	0~255
100		T1 + 500us	fixed value:200

Triple Return Point Cloud Data:

Each packet contains 100 point cloud data, including the first return, the second return and the third return of 34 samples. So the 34th sampling have no second return and third return data. If no multiple returns are detected, the corresponding point data will be set to 0.

Timestamp indicating the time of the first point in the packet. The sampling frequency is 60k, so the time interval of each pulse is 16.666us.

Point Num	Sample Sequence	Timestamp	Reflectivity
1	1	T1	0~255
2		T1	fixed value:200
3		T1	fixed value:250
4	2	T1 + 16.666us	0~255
5		T1 + 16.666us	fixed value:200
6		T1 + 16.666us	fixed value:250
...			
94	32	T1 + 533.312us	0~255

95		T1 + 533.312us	fixed value:200
96		T1 + 533.312us	fixed value:250
97	33	T1 + 549.978us	0~255
98		T1 + 549.978us	fixed value:200
99		T1 + 549.978us	fixed value:250
100	34	T1 + 566.644us	0~255

4. Effects and Limitations

4.1 Effects

For a single laser firing, the normal firmware only reports the first return, while the multi-return firmware can report at most three returns as described above.,

As shown in figure 3, 4 below, Livox LiDAR detects from the air to the ground, the normal firmware can only detect the canopy, while the multi-return firmware can detect returns from the ground.

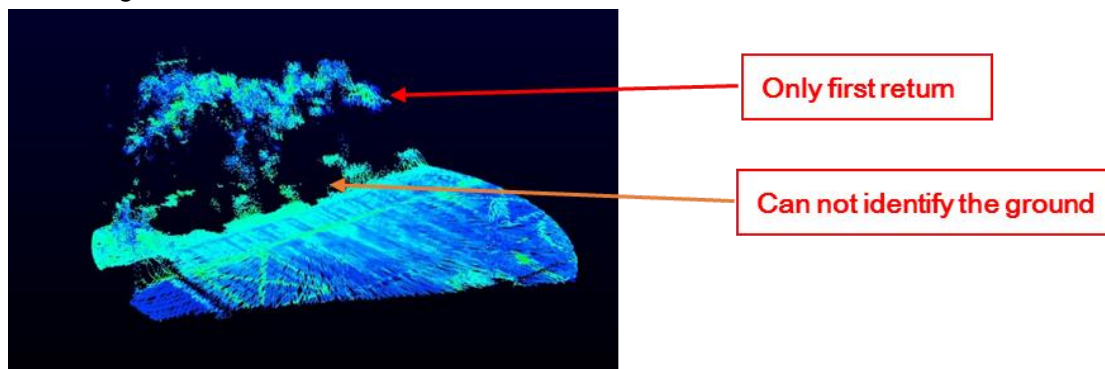


Figure 3 using the normal firmware

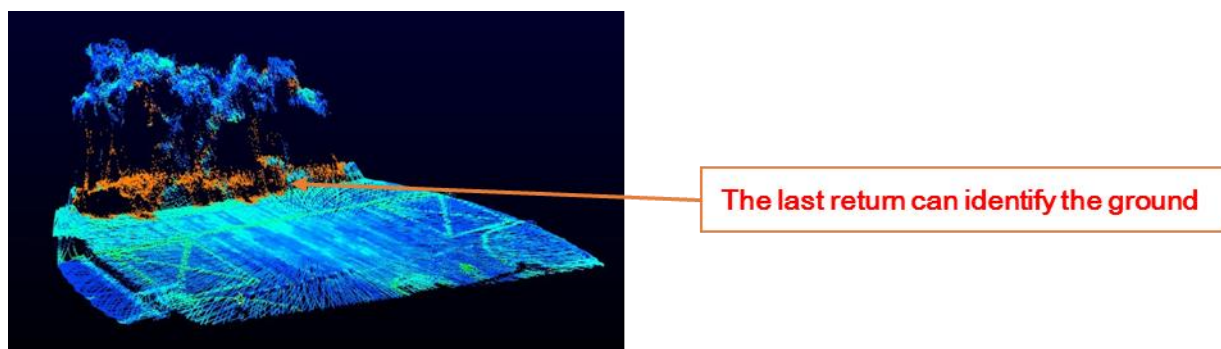


Figure 4 using the multi-return firmware(double return version)

As shown in figure 5, 6, 7 below, a piece of glass is placed in front of the Livox LiDAR. The normal firmware only calculates the depth of the glass. The multi-return firmware (double return version) can not only calculate the depth of the glass, but also the depth of the wall behind. The multi-return firmware (triple return version) can report additional information of another piece of glass in between.

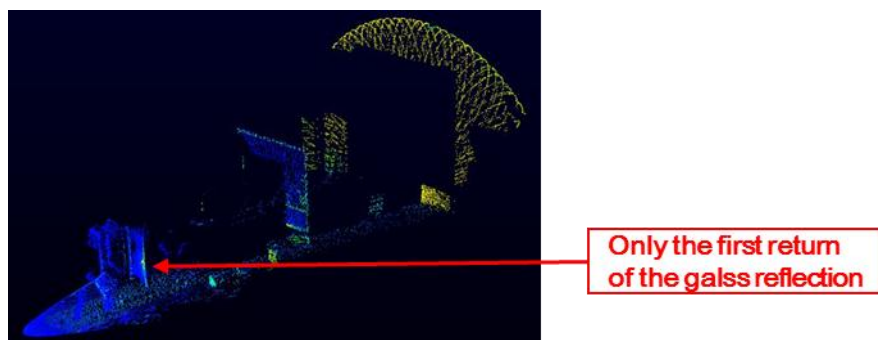


Figure 5 using the normal firmware

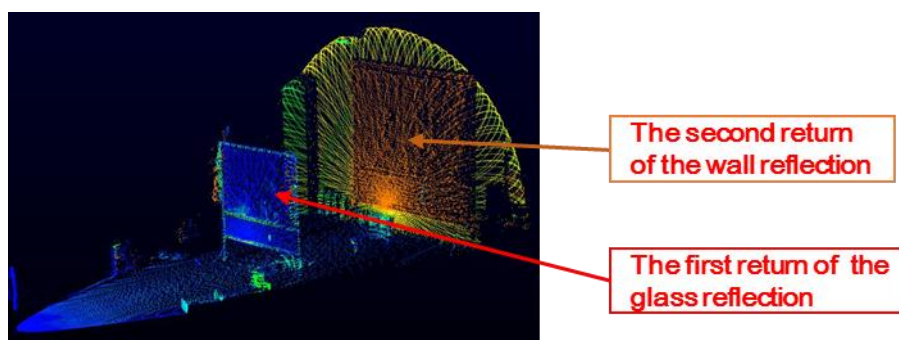


Figure 6 using the multi-return firmware(double return version)

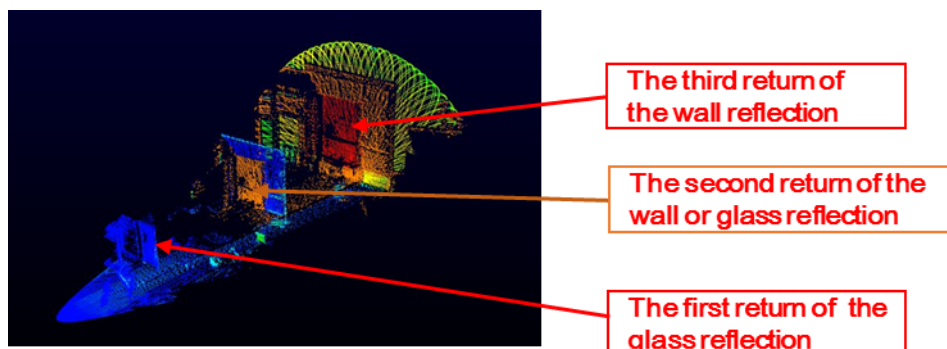


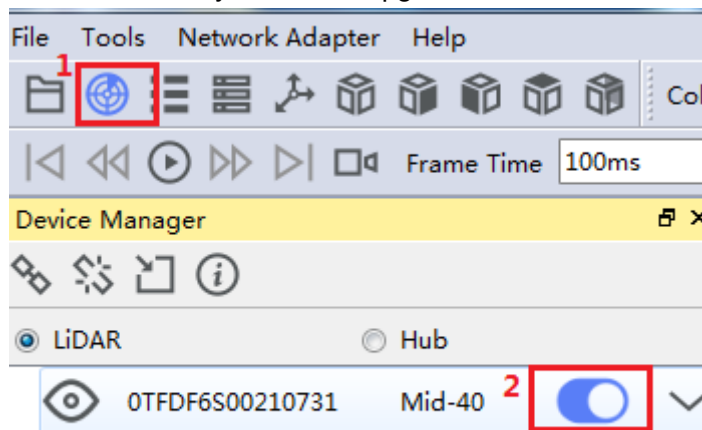
Figure 7 using the multi-return firmware(triple return version)

4.2 Limitations

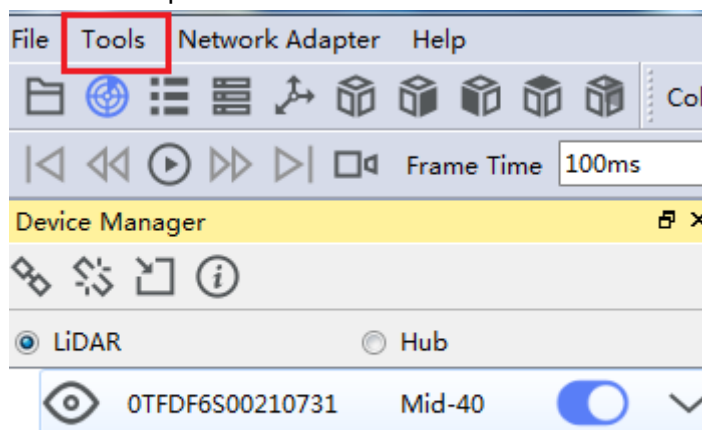
1. For the multi-return firmware, there will be data redundancy in a clean scene (just one return).
2. Multi-return firmware requires a minimum distance gap (typically 2m) between the consecutive objects in the scene to be scanned. Otherwise, the best results cannot be achieved.
3. Multi-return firmware does not support the rain fog suppression.

5. Update Firmware

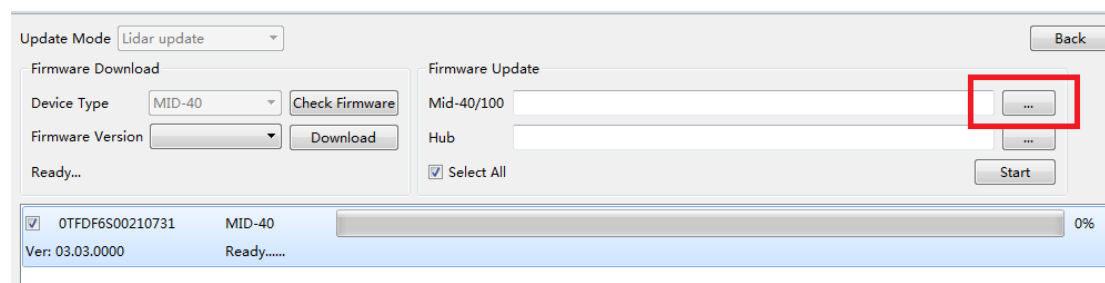
1. Click 'Open Device Manager', a page will appear displaying all detected Livox LiDAR sensors. Connect the device you want to upgrade.



2. Click Tools > Firmware Update.



3. Select the Livox LiDAR sensor you wish to update under "Firmware Update" and click "...".



4. Click "Start" to update the firmware of the selected Livox LiDAR sensor.

Update Mode

Lidar update

Back

Firmware Download

Device Type

MID-40

Check Firmware

Firmware Version

Download

Ready...

Firmware Update

Mid-40/100

E:/LIVOX_MID_FW_03.03.0000.bin

...

Hub

...

☒ Select All

Start

☒ 0TFDF6S00210731

MID-40

0%

Ver: 03.03.0000

Ready.....

5. The Livox LiDAR sensor will restart and reconnect to the computer after the update.

Repeat the steps above if the update fails.

Update Mode

Lidar update

Back

Firmware Download

Device Type

MID-40

Check Firmware

Firmware Version

Download

Ready...

Firmware Update

Mid-40/100

E:/LIVOX_MID_FW_03.03.0000.bin

...

Hub

...

☒ Select All

Start

☒ 0TFDF6S00210731

MID-40

100%

Ver: 03.03.0000

Firmware update success!