PCAP Module Instruction

Introduction

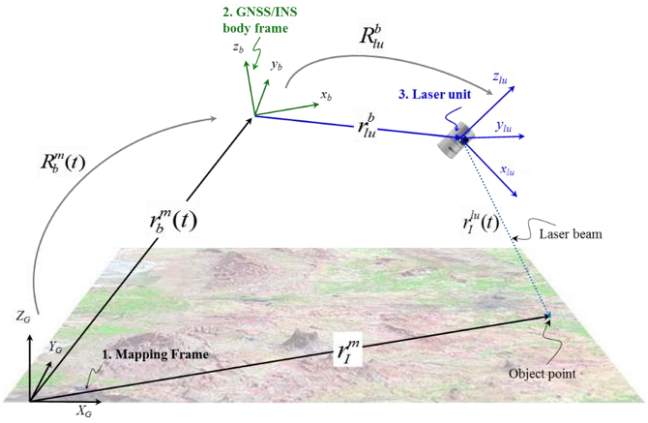
This document is intended to be a quick introduction to the PCAPModule software. It has been divided into two sections, namely, Conceptual Basis of LiDAR Point Positioning and Source Data &Input Data Description.

Caution: In order to run or develop the PCAPModule, WinPCAP software must be installed on the machine. This is to enable decoding of the PCAP files!!

Provided Software and its dependents
PCAPModule_var.exe boost_system-vc120-mt-1_55.dll liblas.dll
Data Source
CPT_08172017_Calibration_US231.bop HDL32E-left-2_00015_20170817132941.pcap
Input Data
config.txt output_files.txt pcap_files.txt calib_files.txt track_times.txt bop_files.txt out_sensors_20170817_ACRE_HDL32E2L.scalib

Conceptual Basis of LiDAR Point Positioning

A typical directly geo-referenced LiDAR system could involve 3 coordinate systems (i.e., mapping frame, IMU body frame, and laser unit frame). A given point, $\boldsymbol{l}$, acquired from a mobile mapping system can be reconstructed in the mapping coordinate system using following equation, which is graphically illustrated in following figure. The coordinates of a 3D point relative to the laser unit coordinate system, $\boldsymbol{r}_{\boldsymbol{l}}^{\boldsymbol{lu}}(\boldsymbol{t})$. An IMU body frame should be considered when mobile systems are equipped with a GNSS/INS navigation unit. For mobile systems, the lever arm, $\boldsymbol{r}_{\boldsymbol{lu}}^{\boldsymbol{b}}$, and boresight matrix, $\boldsymbol{R}_{\boldsymbol{lu}}^{\boldsymbol{b}}$, between laser unit and body frame coordinate systems are time-independent as the laser units are fixed rigidly with respect to the IMU unit. The GNSS/INS integration provides the time-dependent position, $\boldsymbol{r}_{\boldsymbol{b}}^{\boldsymbol{m}}(\boldsymbol{t})$, and rotation, $\boldsymbol{R}_{\boldsymbol{b}}^{\boldsymbol{m}}(\boldsymbol{t})$, relating the mapping frame and IMU body frame coordinate systems.



$$r_I^m = r_b^m(t) + R_b^m(t)\, r_{lu}^b + R_b^m(t)\, R_{lu}^b\, r_I^{lu}(t)$$

Calibration File - out_sensors_20170817_ACRE_HDL32E2L.scalib

The *.scalib files contains the LiDAR system mounting and sensor parameters. The format of the calibration file is as below:

Note: For this project, you only need to modify the LiDAR system mounting parameters and observe the change of the point cloud.

```
!Output Calibration File v0.3
!LiDARSENSORCALIB v1.1
!Sigma0 = 0.0156259822

!SensorName LaserCount
HDL32E2 32


!Calibration Model
0


!Reference Unit ID
HDL32E2
!dx(m) dy(m) dz(m) omega(deg) phi(deg) kappa(deg)(fixed)
-0.0264631204    0.2112906348    0.3200000000    -6.4915169070    1.2163119700    -66.1306038631
!sAlpha delAlpha sBeta delBeta sRange delRange

!LaserID0
1.0000000000    0.0000000000    1.0000000000    0.0000000000    1.0000000000    0.0000000000

!LaserID1
1.0000000000    0.0000000000    1.0000000000    0.0000000000    1.0000000000    0.0000000000

!LaserID2
1.0000000000    0.0000000000    1.0000000000    0.0000000000    1.0000000000    0.0000000000

!LaserID3
1.0000000000    0.0000000000    1.0000000000    0.0000000000    1.0000000000    0.0000000000
```

The one you need to modify
dx, dy, dz are lever arm $\boldsymbol{r_{lu}^b}$
omega, phi, kappa are boaresight angles $\boldsymbol{R_{lu}^b}$

Data Source

BOP File

Body Orientation Parameters (BOP) files contain trajectory information that are collected using GNSS/INS system. After data has been collected by a GNSS/INS system, post-processing is applied to produce a differential GPS based *.bop file. An example BOP file from CPT/IGM is shown below:

```
!BOP File v0.1
!UTCTime      Easting     Northing    H-Ell       H-MSL          Roll          Pitch         Heading         Omega          Phi           Kappa
!(sec)          (m)         (m)         (m)         (m)         (deg)         (deg)         (deg)         (deg)          (deg)         (deg)
74746.00000000   506134.805  4477972.808  186.389      219.980  0.2907200000 -5.5494820000 145.7678950000  4.7535307624  2.8816686090 214.1453242785
74746.00999999   506134.805  4477972.808  186.389      219.980  0.2872940000 -5.5510160000 145.7682390000  4.7528937661  2.8853365342 214.1450062033
74746.01999998   506134.805  4477972.808  186.389      219.980  0.2800190000 -5.5496700000 145.7670610000  4.7476305241  2.8906994693 214.1464505141
74746.02999997   506134.805  4477972.808  186.389      219.980  0.2737670000 -5.5464480000 145.7642530000  4.7413053359  2.8942972253 214.1495800798
74746.03999996   506134.805  4477972.808  186.389      219.980  0.2730790000 -5.5437090000 145.7609280000  4.7384815544  2.8936037350 214.1530451195
74746.04999995   506134.805  4477972.808  186.389      219.980  0.2780440000 -5.5434600000 145.7589040000  4.7409643555  2.8895224901 214.1549355799
74746.05999994   506134.805  4477972.808  186.389      219.980  0.2848980000 -5.5461580000 145.7595460000  4.7470850065  2.8853122320 214.1539750173
```

PCAP File

The *.pcap file is a type of data collected using an Ethernet network connection using a User Datagram Protocol (UDP). Data acquired by this method are encoded in a hexadecimal format, and need to be decoded before acquiring LiDAR point cloud information.

Input Data

config.txt:

- Configuration file settings are explained in the screenshot below:

```
!PCAP Module Configuration File
!Please retain the same order for the configuration (Inertial sensor, Range, Azimuth)

!Inertial Sensor | IGM,CPT = 0, APX15 = 1 (set as zero in the program by default)
0

!Range Threshold (in meters) // Set as a range!!
!Exclude ranges greater than the value below
3   30

!Azimuth Threshold Range (in degrees)
!Exclude points which fall in the range below (make the value as -1 if not required)
!Example: Phenomobile = 75 285, S1000+ = 30 330,...
-1  -1

!LaserID Range
!HDL32E = 0 - 31, VLP16 = 0 - 15
!Example IDs: 0-5 = 0 5; All LaserID's = -1 -1
0   31

!Output in Laser unit coordinate system
!Example, 0= mapping frame, 1 = laser unit frame
0

!Odd/Even Laser beam output
-1

!Time Offset
0

!Number of Thread
1
```

pcap_files.txt

- List of input PCAP files for processing
- Contains the absolute location path to the pcap files to be processed

```
D:\Run\ReconstructionTutorial\Data\HDL32E-left-2_00015_20170817132941.pcap
```

scalib_files.txt

- List of calibration files for processing
- Put the *.scalib file in the same folder with provided software
- Contains the name to the scalib files to be processed

```
out_sensors_20170817_ACRE_HDL32E2L.scalib
```

bop_files.txt

- List of BOP Files for processing
- Contains the absolute location path to the bop files for processing.

```
D:\Run\ReconstructionTutorial\Data\CPT_08172017_Calibration_US231.txt
```

output_files.txt

- List of file names for LAS output
- Contains the name of processed output LAS files.

```
!File names for the LAS output file
TestData
```

track_times.txt

- Set the time range for the generated point cloud

```
!TrackID startTime(millisec) endTime(millisec)
!fileIndex1, fileIndex2, fileIndex3 (file index corresponds to the index of the pcap file in the program)
1    63074140    63088530
0    -1   -1
```

PCAPModule: How to run?

- After setting all the input file, double click the “PCAPModule_var.exe”
- PCAPModule first reads the input configuration file (config.txt), line by line. Hence, it is important to keep the same input configuration order.
- It then proceeds to read the pcap_files.txt, bop_files.txt, calib_files.txt and output_files.txt, also, line by line
- The corresponding line of each file is linked to each other, to generate the output in LAS format