Data Compression of Airborne Laser Scanner Data

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Abstract: The usual method for interpretation of collapsed building after any calamity is differential comparison using 3-dimentional data acquired by airborne laser scanner. However, the transmission of the huge amount data to a ground base station in real time has been a big problem. In this research, a realizable compression technique is studied in which the point density required for calamity interpretation is set up and the rate of compression required for the transmission to the ground with the present access speed is defined.

1. Introduction

One of the methods that can automatically find the area of destroyed buildings caused by the disaster is to compare the digital surface models between before and after the disaster. It is difficult to transmit the huge laser scanner data acquired from the airborne to the ground station at the moment. However, in this study, the laser point density needed to judge the disaster was determined as the buildings were target, and the compression ratio was evaluated to transmit acquired data to the ground by the current transmission ratio. Although, the compression ratio was not satisfied using the standard compression methods, a compression method on real time from mission was realized and suggested.

2. Definition of the target compression ratio

2-1. The transmission ratio from airborne to the ground

It is reported that the airborne transmission of captured data on real time was successful using N-STAR satellite by the National Institute of Information and Communication Technology. Experiments were also made to consider using the ultra high-speed Internet satellite, WINDS. The maximum transmission ratio was 6.0 Mbps from these reports, and the actual transmission rate was defined as 3.0 Mbps in this study as the transmission efficiency was assumed to be 50 %.

2-2. Laser point density and acquisition conditions

The area of the ground structure was determined from the 3D model in a city, and the minimum area for the building structure was defined. Fig. 1 shows the distribution of the surface area of the structures. The distribution of the surface area for each structure was calculated, and the minimum area defined as thebuilding was set to 20 m^2. Then the minimum number of pulse needed to judge the shape of the building was set 4 pulses, and the flight plan was decided by this precondition. Table 1 and 2 show the specifications of the data acquisition and the amount of the acquired data, respectively.

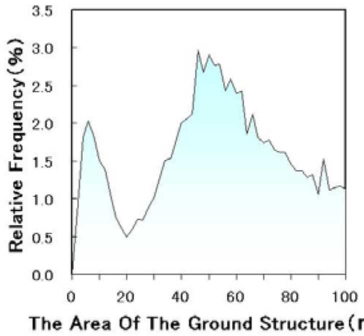


Fig. 1. The uctures.

Table 1. The specifications of data acquisition.

Time	1.05 H
FOV	40 degree
Altitude	6500 ft AGL
Flight speed	110 knots
Pulse rate	45000 Hz
Scan rate	24.44 Hz
Laser side lap	30 %
Cross track [max]	2.10 m
Along track [max]	2.32 m
Point density [min]	0.205 points/m^2

Table 2. The amount of acquired data.

Data content	Data amount
Pulse data	3881 MB
GPS/IMU data	214 MB

2-3. Calculation of the target compression ratio

The compression ratio needed to transmit data to the ground was calculated by converting from the amount of pulse data and GPS/IMU data acquired by the airborne at specified time. The compression ration needed to transmit the data by the effective transmission ratio is less than 20 %, and this figure is the target of the compression ratio in this study.

3. Analysis of airborne laser data

3-1. Characteristics of the laser pulse data

The pulse data acquired from laser scanner consisted of the 3 kinds of binary data, the laser launch time, the mirror angle, and the return pulse time (Fig. 2). The most suitable compression method was selected by the data characteristics. The continuity of the laser launch time, the mirror angle, and the return pulse time is shown in Fig. 3, 4, and 5, respectively. The result shows that the shape of the laser launch time is the straight line to the line number, the mirror angle is the sine curve, and the return pulse time reflects the structure of the land surface on the sine curve including the noise.

The compression method consists of two processes, changing the most suitable format and coding the data. The compression method was examined by the amount of data and the compression ratio derived from the entropy effect for 3 kinds of data. Table 3 shows the comparison of 4 kinds of compression methods considered from the mirror angle data.

The mirror angle data determine the laser launch direction, and it is recorded by the same cycle of the launch. The quadratic difference method was selected as a most suitable compression method from the mean amount of the data and the effect of the entropy.

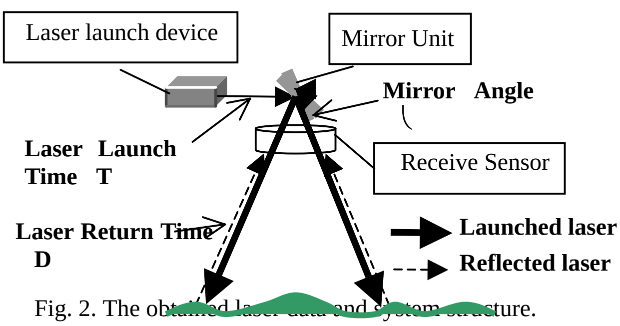


Fig. 2. The obtained laser data and system structure.

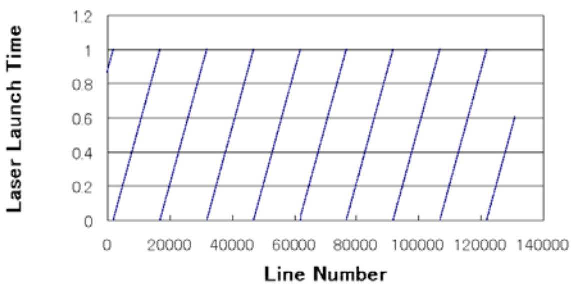
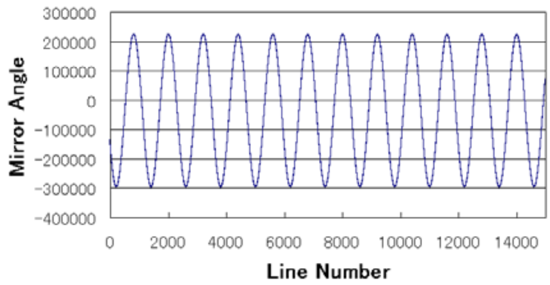


Fig. 3. The laser launch time data.



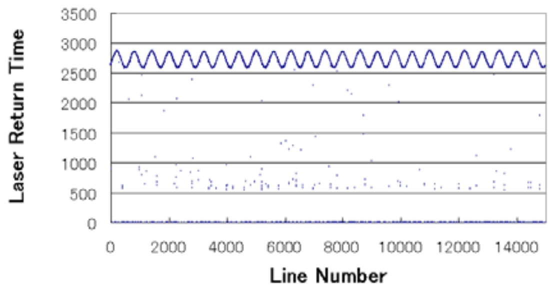


Fig. 5. The return pulse time data.

Table 3. The comparison of 4 kinds of compression methods.

Compression data format	Mean amount of data [Byte]	Entropy compression effect
Static sine approximation	1.96	Low
Dynamic sine approximation	1.83	Middle
Near difference method	1.94	Middle
Quadratic difference method	1.01	High

3-2. Analysis of the GPS/IMU data

GPS/IMU data file consists of observed GPS data and IMU data. GPS data and IMU data was separated by internal format, and most suitable compression method was determined from the characteristics of each data. Fig. 6 and 7 show the frequency of x-axis acceleration and angle acceleration data by difference method, respectively. From the same analysis of 3 axes acceleration and angle acceleration, effective entropy effects were obtained by using the linear difference method.

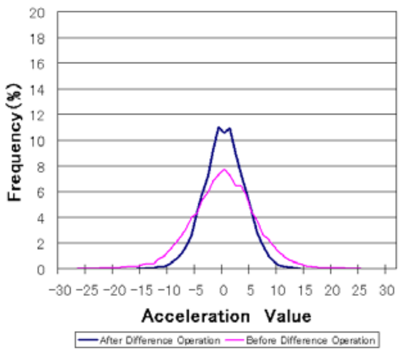


Fig. 6. Frequency of x-axis acceleration and the difference data.

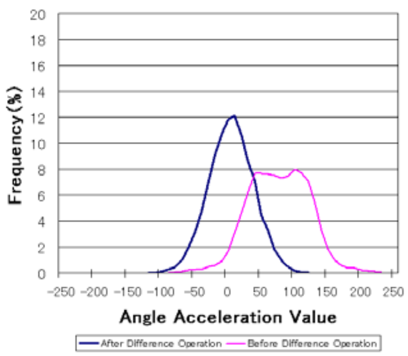


Fig. 7. F lifference data.

4. The adopted compression method

Table 4 shows the compression method using in this study. The method for each compression method is following. The i-th laser launch time data, mirror angle data, and GPS/IMU data is y_i and return pulse data at the time t is P_t. The linear difference (D_i) of GPS/IMU data expressed as equation 1is preserved.

$$D_i = y_i - y_{i-1} \quad (1)$$

The quadratic difference (DD_i) of laser launch time and mirror angle data expressed as equation 2 is preserved.

$$DD_i = D_i - D_{i-1} \quad (2)$$

Fig. 8 shows the original data of the return pulse data.

The existing probability of high-level return pulse data is low, and the compression effects by the difference method between same-level return pulse data are not sufficient. So the difference method dividing 2-axes of pulse time (difference between same array data) and n-th return pulse (difference between same line data) was selected. When the difference data of n –th array at pulse time t is D_{nt}, the linear difference data of 1st array is calculated by equation 3, and return pulse data after 2nd array is calculated by equation 4 and 5.

$$D_{1t} = P_{1t} - P_{1t-1} \quad (3)$$

$$D_{2t} = P_{2t} - P_{1t} \quad (4)$$

$$D_{3t} = P_{3t} - P_{2t} \quad (5)$$

The method preserved the difference data by such equation is defined as the combination difference method between time and pulse

Fig. 9 shows the flow of the process. In actual processing, the data converted by each compression method is output as the compression data through the coding process (PPMD method).

Table 4. The comparison of the method using in this study.

Data	Method
GPS/IMU	Linear difference method
Laser launch time	Quadratic difference method
Mirror angle	Quadratic difference method
Return pulse time	Combination difference method

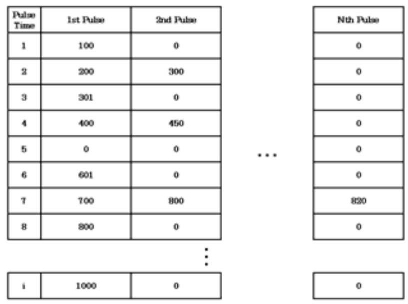


Fig. 8. The original data of the return pulse data.

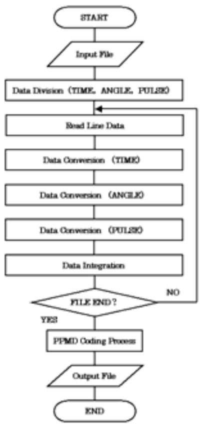


Fig. 9. The flow of the process.

5. Results

Table 5 shows the comparison between the proposed method and the general method for pulse data. Table 6 shows the compression results of airborne data using the compression method in this study.

From these results, the higher compression result for the laser data is obtained from the proposed method than the general method. It is confirmed that the compression ratio necessary to transmit on real time (20 %) is accomplished in this method.

Table 5. The comparison between the proposed method and general method for pulse data.

Compression method	Compression rate (pulse data)
In this study	12.53 %
ZIP	45.88
LZH	16.98
CAB	29.90
TAR-GZIP	44.96

Table 6. The compression results of airborne data using the compression method in this study.

Pulse data	9.07 %
GPS/IMU data	48.15
Sum	11.12

6. Conclusions

The compression method proposed in this study is used at airborne observation, the time lag from data acquisition to landing is canceled, and it is useful in the cases at the time of the disaster.

Although the loss-less compression method is adopted now, we examine the compression method which removes noise data on ground process, and improves to fit this compression method also to the data acquired at the higher pulse rate to transmit the data earlier.

References:

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