A STUDY ON GENERATION METHOD OF DSM FOR FOREST CANOPY USING A 2D LASER SCANNER AND STEREO PAIR IMAGE

S. Taira [a, *], Y. Honda [a], K. Kajiwara [a]

[a] Center for Environmental Remote Sensing (CEReS), Chiba University, Japan - s.taira@graduate.chiba-u.jp

Commission VIII, WG VIII/7

KEY WORDS: Forestry, DSM, LIDAR, stereo matching, helicopter observation

ABSTRACT:

It is thought that the use of bidirectional reflectances measured by satellites enables the estimation of vegetation biomass. We have developed a simulator to estimate the bidirectional reflectance, in order to develop and validate algorithms using bidirectional reflectance. This simulator is used to calculate three-dimensional model, and the result greatly depends on the accuracy of 3D model to use. Therefore, I propose a method to correct the angular data of the helicopter. If the measurement is along with a helicopter equipped with laser scanner and digital camera, relative position of the image data taken by digital camera and laser range data can be easily noticed. In this fact, angle can be calculated with simple math.

1. INTRODUCTION

One of the causes of global warming is the rise in atmospheric carbon dioxide. Because the plants have the ability to fix atmospheric carbon dioxide, monitoring of vegetation biomass is important to know the carbon cycle.

It is thought that the use of bidirectional reflectances measured by satellites enables the estimation of vegetation biomass. So, we have developed a simulator to estimate the bidirectional reflectance, in order to develop and validate algorithms using bidirectional reflectance. This simulator is used to calculate three-dimensional model, and the result greatly depends on the accuracy of 3D model to use.

2. ISSUE

We used a radio control (RC) helicopter and laser-scanner to get Digital Surface Model (DSM) to simulate bidirectional reflectance. When a RC helicopter is equipped with measuring instruments, it is possible to increase the data density by lowering the speed of helicopter in the direction of flight. But, this method has the following problems, which should be solved for their improvements:

1. Error due to measurement range of laser scanners.
2. Gyro error of RC helicopter.
3. Invisible hit area of the laser.
4. The structure smaller than the laser spot size are not reflected in DSM.
5. Difficult to improve the data density in the direction perpendicular to the direction of the helicopter.
6. Independent vibration of helicopter camera platform.

3. PURPOSE

The purpose of this study is to develop a methodology for the creation of high resolution DSM with low error by solving those six problems mentioned above.

Figure 1. Radio control (RC) helicopter made by YAMAHA Motor Co., Ltd.

Angle measurement accuracy	±0.2°
Operating speed	0.1m/s~7m/s
Operating altitude	15m~150m

Table 1. Specification of radio control (RC) helicopter

Therefore, we should first think about a method to improve accuracy of position and angular measurement of the instrument. By using Global Positioning System (GPS), position measurement can be measured by the error of around ± 1cm. However, because of the error due to independent vibration of helicopter camera platform and due to the gyro error of helicopter, the accuracy of angular measurement is low. This allows data to be measured in the horizontal direction with an error of 10 cm or more (when the helicopter altitude is 30 m). Therefore, I propose a method to correct the angular data of the helicopter.

Figure 2. The SICK Laser Measurement Sensor (LMS) 200

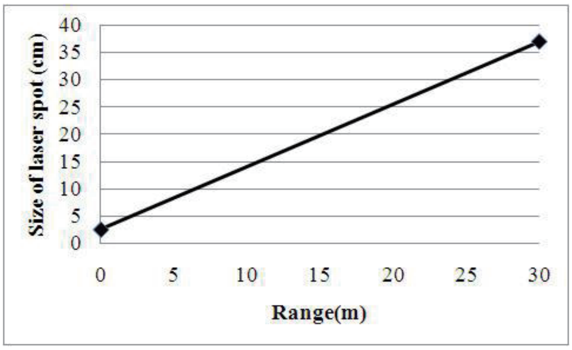

Figure3. Relation between range and size of laser spot of the SICK Laser Measurement Sensor (LMS) 200

Effective range	～60m
Recording resolution	1cm
Angular resolution capability	0.5°
Weight	3.0kg
Recorded data	Distance, Angle
Recording frequency	38.0Hz/1line (180°)

Table 2. Specification of the SICK Laser Measurement Sensor (LMS) 200

4. PURPOSED METHOD

If the measurement is along with a helicopter equipped with laser scanner and digital camera, relative position of the image data taken by digital camera and laser range data can be easily noticed. In other words, the distance between the pixel data and measuring instruments can be known from some image pixels that recorded the color data in the same direction to laser scanners. The value of laser range data is relatively accurate. It is assumed that this value is true. Then, we could create a more accurate DSM, by correcting the angular data which determines the distance of the scanner results by measuring the height of the canopy from two images. On the other hand, a tangible way is thought. First, stereo match is taken by overlapping two images, then the canopy elevation data is obtained by using GPS, gyroscope, and camera images. At the same time, laser scanning data is measured. Some pixels of the images taken by camera has location information inferred by stereo matching, and they also have location information measured by laser scanner. Here, it is defined that the data have two positions. Here, $\overrightarrow{O_1L_k}$ is named for the laser range data of the k-th pixel (k = 1, 2, 3, ...,n), $\overrightarrow{O_1M_k}$ is named for the coordinates of the k-th pixel by stereo matching, O_1 is named for the coordinates of the left instrument, and O_2 is named for the coordinates of right instrument (Figure 4). Those two estimated coordinates should be the same as original. However, they do not match as we know the exact angular information of the instrument. Then, $\overrightarrow{\varepsilon_k}$ is defined as the difference between $\overrightarrow{O_1L_k}$ and $\overrightarrow{O_1M_k}$. At this time, you can write the following equation:

$$\begin{aligned}\overrightarrow{\varepsilon_k} &= \overrightarrow{O_1L_k} - \overrightarrow{O_1M_k} \\ &= \overrightarrow{O_1L_k} - (\overrightarrow{O_1O_2} + R\overrightarrow{O_2M_k})\end{aligned} \quad (1)$$

(R is a rotation matrix representing the error of the instrument with the right angle. In addition, the model coordinate system to choose the instrument with the left coordinate system).

In this case, $\overrightarrow{\varepsilon_k}$ should be obtained from the instrument with the right attitude by seeking the smallest. Measuring instruments based on correct posture angle obtained by this calculation, the correct attitude errors can be matched once again by stereo instrument with DSM created.

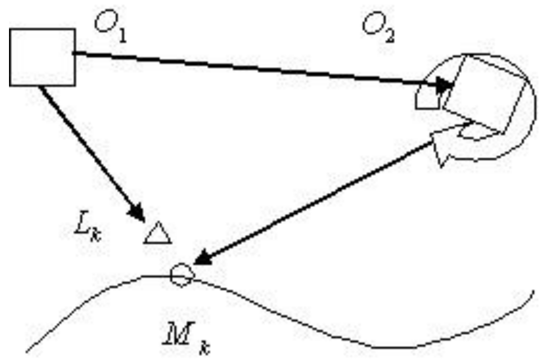

Figure 4. The conceptual image of measurement method

5. CONCLUSION AND PLAN

In order to obtain high resolution DSM, a methodology has been developed. This methodology enhances the accuracy of the attitude of the measuring instrument. In the future experiment, the ground measurements of the robot arm, which can be measured in the test instrument with a clear stance, will be analyzed. It is hoped that the future experiment will be useful in validating the methodology so far developed.