# DEVELOPMENT OF 3D STRUCTURE MEASUREMENT SYSTEM USING LASER SCANNING DATA AND CCD SENSOR

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**ABSTRACT:**

When the data from the artificial satellite is analyzed, recent years it is perceived to vegetation index using BRF(Bi-directional Reflectance Factor) of the observation target. To make the BRF models, it is important to measure the 3D structure of the observation target actually. In this study, it is proposed to the observation technique by using laser scanning data.
Also, our team has been operating the radio controlled helicopter which can fly over the tall forest canopy and it can be equipped the measurement system.

**KEY WORDS:** Vegetation structure, laser scaner, RC helicopter

## 1. INTRODUCTION

For the vegetation monitoring, especially for estimating the vegetation quantity, it is required to develop the estimation model which is based on ground measurement. As well known, there are some difficulties to understand the characteristics of reflected light response against incident light on canopy caused by the influence of sun light reflection behaviour by canopy structure. For developing the model describes spectral response from canopy structure, the above relationship should be clarified by ground measurement. For this reason, it is necessary to obtain canopy structure, and the various methods have been devised.

## 2. OBJECTIVE

The purpose of this study is to obtain the 3D structure and images of the observation target.

## 3. DEVELOPMENT OF THE OBSERVATION SYSTEM

### 3.1 Propose the observation system using the laser scanner

For obtaining the 3D structure of the observation target, the technique of image matching for stereo pair image is widely used. But this technique causes the following problems. 1) Increasing the invisible area and make many 'hole' in focused area. 2) In a forest, it is difficult to search matching points from stereo pair image. Since the form is complicated in the forest.

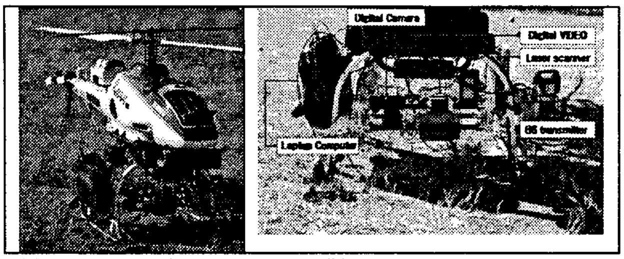
By the way, Laser scanner able to directly measure the distance of the object. In this paper, propose the observation system using the laser scanner.

### 3.2 Developed measurement system using RC helicopter

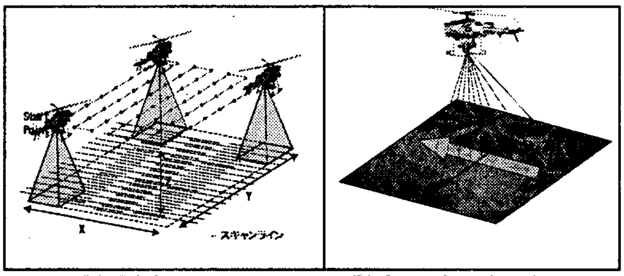
To measure the tall forest canopy structure, our team selected autonomous RC helicopter (YAMAHA R-MAX, Figure 1(a)) as platform, because this platform has not only higher mobility and static stability, but also lower cost than other one. This helicopter flies in accordance with a flight plan that has been programmed in the Attitude control system) and the differential GPS system. By setting a moving direction, speed etc. on a PC monitor that is set up on Ground Station System, the helicopter can move in the three-dimensional space on a real-time basis. Also, the RC helicopter can move automatically in accordance with the coordinates assigned in the map data on the PC. The operator can easily operate a programmed flight by combining the coordinate points.

Our team did the development of the observation system (Figure 1 (b)) that does automatic data acquisition. In this observation system, RC helicopter mounted Laser scanner and Digital Camera and other equipment. Laser scanner

can obtain 3D structure of the observation target and the digital camera can take image at optional interval time.
Figure 2 is shown the situation of obtaining data.



(a) YAMAHA "RMAX" (b) Measurement system
Figure 1. RC helicopter measurement system


(a) Fright pattern (b) Scanning situation
Figure 2. Situation of obtaining data

By using Eq. (1), acquire the DSM(Digital Surface Model) of the observation area, where it is transformed Geometric coordinate on the basis of the heliport.

$$P'_{i,\theta_j,r_j} = P'_{scan\_i} + r_j * R(\omega,\varphi,\kappa)$$

(1)

$P'_{i,\theta_j,r_j}$ = Geometric coordinates of measured point
$P'_{scan\_i}$ = Geometric coordinates of RC helicopter
$r_j$ = Measuring distance in the each angle
$\omega$ = Pitch, $\varphi$ = Roll, $\kappa$ = Yaw

$$R(\omega,\varphi,\kappa) = \begin{pmatrix} \sin(\theta_j+\varphi)*\sin(\omega)*\sin(\kappa)+\cos(\theta_j+\varphi)*\cos(\kappa) \\ \sin(\theta_j+\varphi)*\sin(\omega)*\cos(\kappa)-\cos(\theta_j+\varphi)*\cos(\kappa) \\ -\sin(\theta_j+\varphi)*\cos(\omega) \end{pmatrix}$$

(2)

## 4.CONSIDERATION OF OBTAINED STRUCTURE DATA

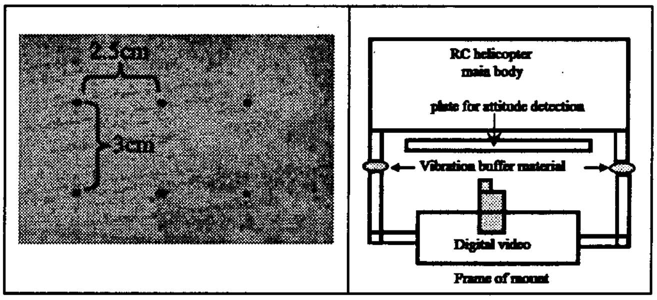
### 4.1 Attitude detection of mount

We did the data acquisition in the landslide area. Because this lay of the land is easy to recognize the boundary line clearly and the difference of elevation, it is suited to the inspection of measurement accuracy.

When seeing the data, many noises are included to the structure data that was acquired (Figure 3). It is for this reason that mount is inclined to the RC helicopter. So, it is necessary to detect the attitude to the RC helicopter of the mount.

To detect the attitude to the RC helicopter of the mount, attached the plate for attitude detection (Figure 4 (a)) and attached a video camera that shoots the plate from mount (Figure 4 (b)).

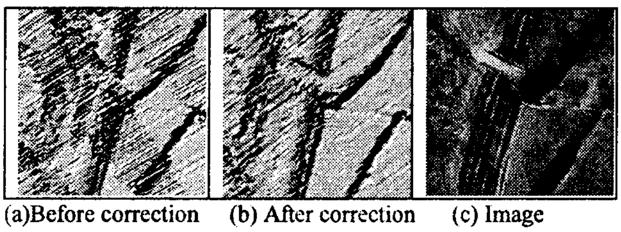

(a) Structure data (b) Image
Figure 3. Structure data and image



(a) Plate for attitude detection (b)Composition of equipments
Figure 4. Detect the attitude to the RC helicopter of the mount

The method is to continue shooting the plate with the digital video during a flight. It is able to obtain the attitude to the RC helicopter of the mount analyzing the movement of the plate in the motion-image. By using the attitude of the mount that was obtained, correct the observational error.

The results of this correction are shown in Figure 5.


(a)Before correction (b) After correction (c) Image
Figure 5. The results of this correction

### 4.2 Accuracy of structure data

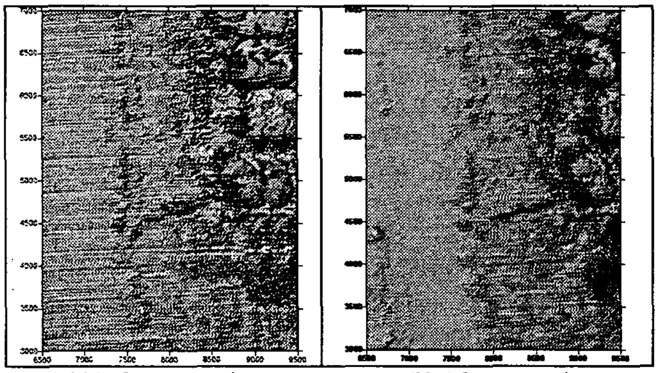
It is compared structure data with eleven points of the land making a survey. The average RMS error of data is calculated by the comparison. The results of this comparison are shown in Table 1.

Table 1. RMS error of structure data

| | RMS error |
|---|---|
| X(cm) | 25.4 |
| Y(cm) | 25.2 |
| Z(cm) | 14.1 |

## 5. ACQUISITION OF THE STRUCTURE DATA OF CANOPY

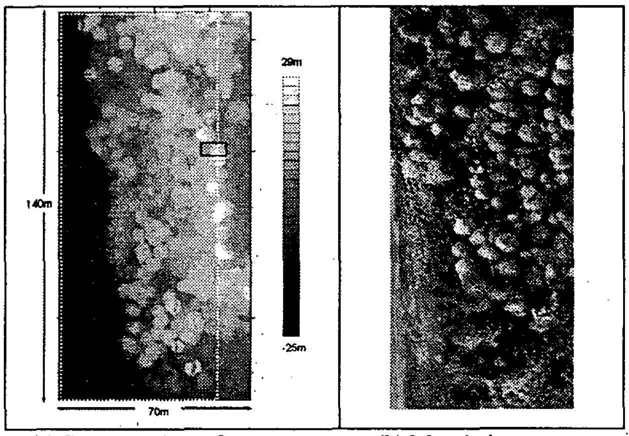
It was checked whether the correction method acts effectively also in other observation places. The place is the road near the forest where the laboratory is managing. The results of this correction are shown in Figure 6. Figure 6(b), noise decreases in comparison with Figure 6(a) and recognize that the form of the road become more clearly.



(a)Before correction (b) After correction

Figure 6. The results of correction

Canopy measuring flight was carried out in the same observation day. Using above correction method, the obtained data is corrected and acquired canopy structure (Figure 7). It recognizes that the structure of canopy is obtained clear from Figure 7(a).




(a) Structure data of canopy (b) Mosaic image

Figure 7. Structure data of canopy and mosaic image

## 6. CONCLUSIONS

In this study, canopy structure measurement system that installed the laser scanner to RC helicopter was developed. The developed system has been tested in the landslide area. Further, canopy structure was obtained at the forest where the laboratory is managing.

## 7. ACKNOWLEDGEMENTS

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