Development of New Method for Field Survey of Stand Parameters on Mangrove Forest — A Kind of Remote Sensing in the Forest —

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Abstract

It is difficult to measure tree height, trunk volume and so on for many trees in mangrove forest. But it is necessary for calculation of stand parameters such as the average of them. We have calculated trunk volume of a tree by conventional ways that are to measure diameter at each height with intervals of some meter by climbing up or cutting down a tree. If it is not allowed to cut down trees, we measure diameter at each height by climbing. But the measurement is hard, riskful and not expected with accuracy.

We tried to develop a new method with combination a pole composed of drawtubes and a digital camera operated by remote control. Six laser pointers were parallelized in a box fixed bellow the camera, and the unit composed the box and camera was fixed at the top of drawtubes, could be panned horizontally. Red points on a trunk with laser pointers functioned as scales. It was useful against many trees at different distance, and it became possible to know a diameter at any height on a taken imagery zoomed in. This method is a kind of remote sensing in the forest.

With main two improvements introduced in the first prototype for three years, this method has been almost completed. And it became safe and easier to collect data for stand parameters of mangrove forest combined to the satellite data.

1. Introduction

The information on stand parameters of mangrove forest was almost unknown approximately twenty years ago, because mangrove forest had been classified as the other forest except primal forests. Recently, the importance of mangrove forest has been recognized in the global environment and the coastal ecosystem.

In forestry we are mainly concerned to know the volume of trunks and we measure diameter at breast height (DBH) and tree height to estimate the volume. After measurement of DBH or tree height, we must make clear correlation between them and trunk volume, and obtain regression equations among them. Although it is difficult to measure parameters on the form of trees than the crop, the tables and equations have been improved for estimation of trunk volume by DBH and tree height for primal forests. Collection and integration of the information on the mangrove forests intend to be started, but it is more difficult than the ordinary land forest because of deep muddy sedimentation and complex prop roots, knee roots and erect roots.

We have calculated trunk volume of a tree by conventional ways that were to measure diameter at each height with intervals of some meter by climbing up or cutting down a tree. If it is not allowed to cut down trees, we measure diameter at each height by climbing. But the measurement is hard, riskful and not expected with accuracy. As it is necessary to measure the distance between a trunk and an instrument for measurement of a vertical angle to the tip of tree, the measurement of tree height of mangrove also is hard because of the site condition. Furthermore it is not easy to find a point where the tip of tree can be penetrated many leaves and branches.

The purpose of these serial studies was to develop an efficient method without hardness and riskiness introducing the point of view of remote sensing into the field survey in mangrove forest. The data of stand parameters are needed for the analysis on the relationships between satellite data and stand parameters of mangrove forest. Such analysis should be useful to grasp update and broad circumstances on mangrove forest as fundamental information for sustainable management and control of it.

2. Methodology and prototypes

We had read remote sensing works for meanings of actions in the conventional ways mentioned above. They were to measure diameter of trunk at a height, and to estimate the distance from the highest position can be climbed to the tip of trunk by eyeballing with a guide rod. The former was read for taking photograph of trunk at a height and the latter for measuring the height of camera where the tip of trunk can be seen in the center of view

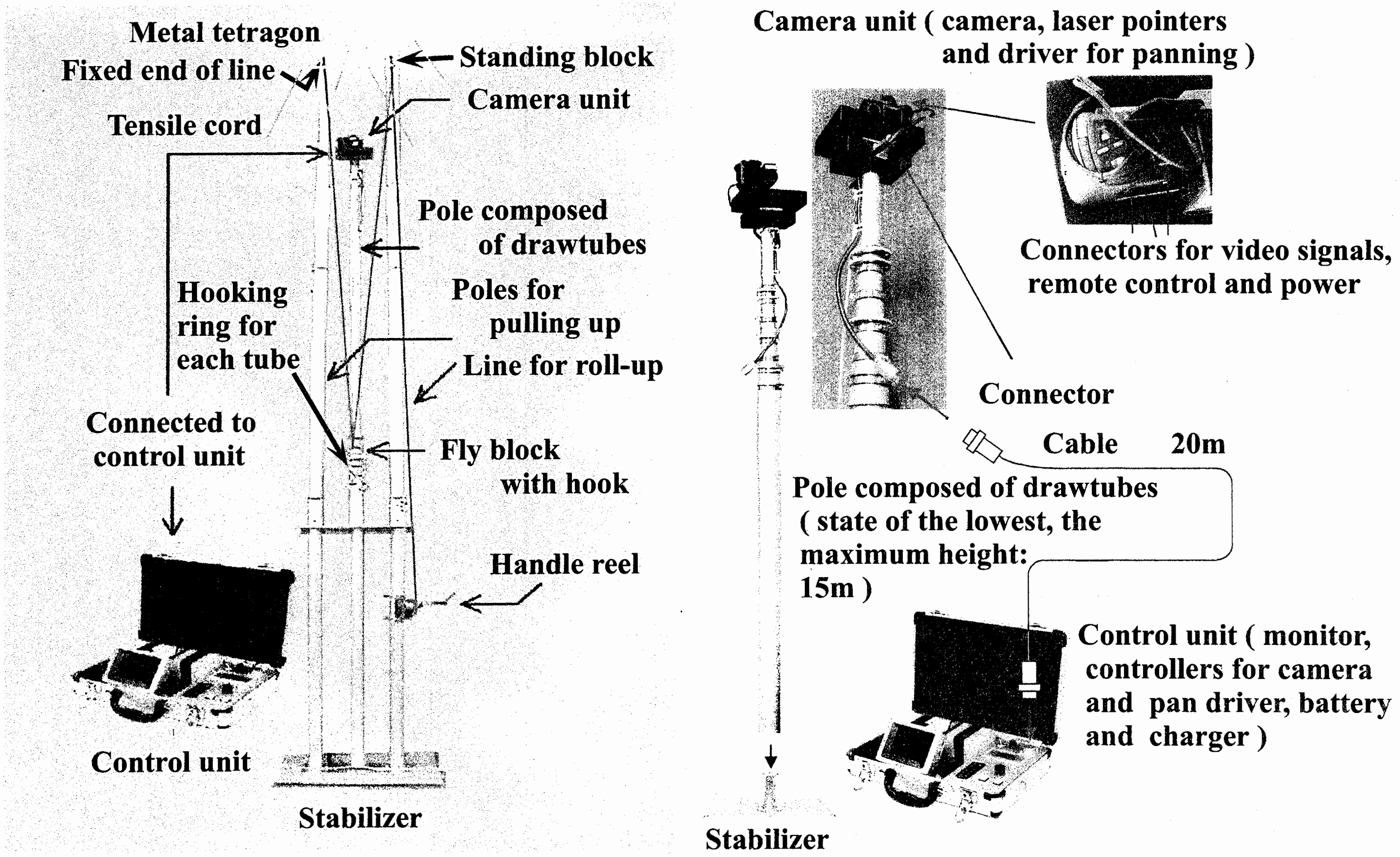

Fig. 1 The first prototype of this method (right:ACRS'01) and improved prototype (left:ACRS'02)

Fig.2 Conventional way (left above) and circumstances of measurement by the first and second prototype

finder, with a fine surveyor's tape fixed zero to the side of camera. The volume of a trunk can be calculated from the sectional measurement of volume that sum up volumes of several frustums and a tip cone.

In these serial studies, a digital camera was adopted. The main reason was that it was difficult to develop films and print pictures in the field. Certainly it is possible to calculate using developed and printed pictures later, but it becomes difficult to keep correspondence between measurement and the panel in films. Using a digital camera, it is easy to assemble and process imageries in a day. The assurance and mobility with a digital camera is higher than an ordinary film camera. If the process on the measurement of trunk diameter is systematized and programmed, it becomes possible to calculate trunk volume in the field.

For calculation of trunk diameter on an imagery or picture by a digital or a film camera, it is necessary to know the focal length of a camera and the distance from the camera to an objective trunk. But measurement of the distance by walk is hard as mentioned above. As a solution for this problem, we applied several laser pointers. Six laser pointers were parallelized and fixed in a box and laser beams were irradiated through six apertures of the box. As red points on a trunk by laser irradiation work as several length scales, the diameter at a height of camera supported by the pole can be calculated with these scales regardless of the distance from the camera or zoom ratio. So it becomes no need to measure the distance between a trunk and the pole against some target trees.

Our prototype was composed with a pole, camera unit and control unit. The composition and connection of this system were shown Fig. 1.

The first prototype was reported at ACRS'01[1)] and improved it reported at ACRS'02[2)]. The main improvements introduced in the first prototype were two points. First point was a handle reel and two poles combined at the top for pulling drawtubes up[2)]. Second point was the devise for self-leveling of the camera unit at the top of drawtubes. This point was reported in this paper. The self-leveling of the camera unit was shown in Fig. 3.

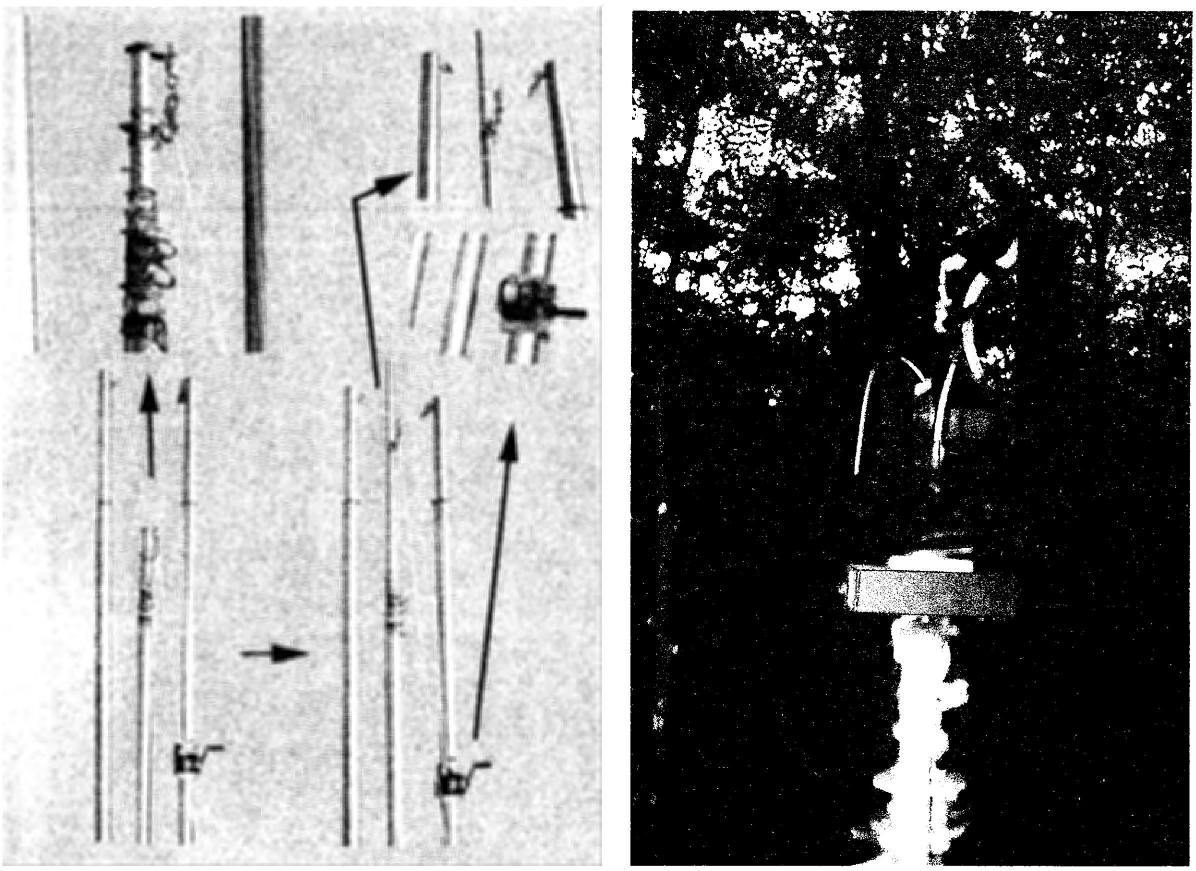

Fig.3 Operation of hook, string and handle reel for pulling drawtubes up (left) and the final improvement of self-leveling of camera unit (right)

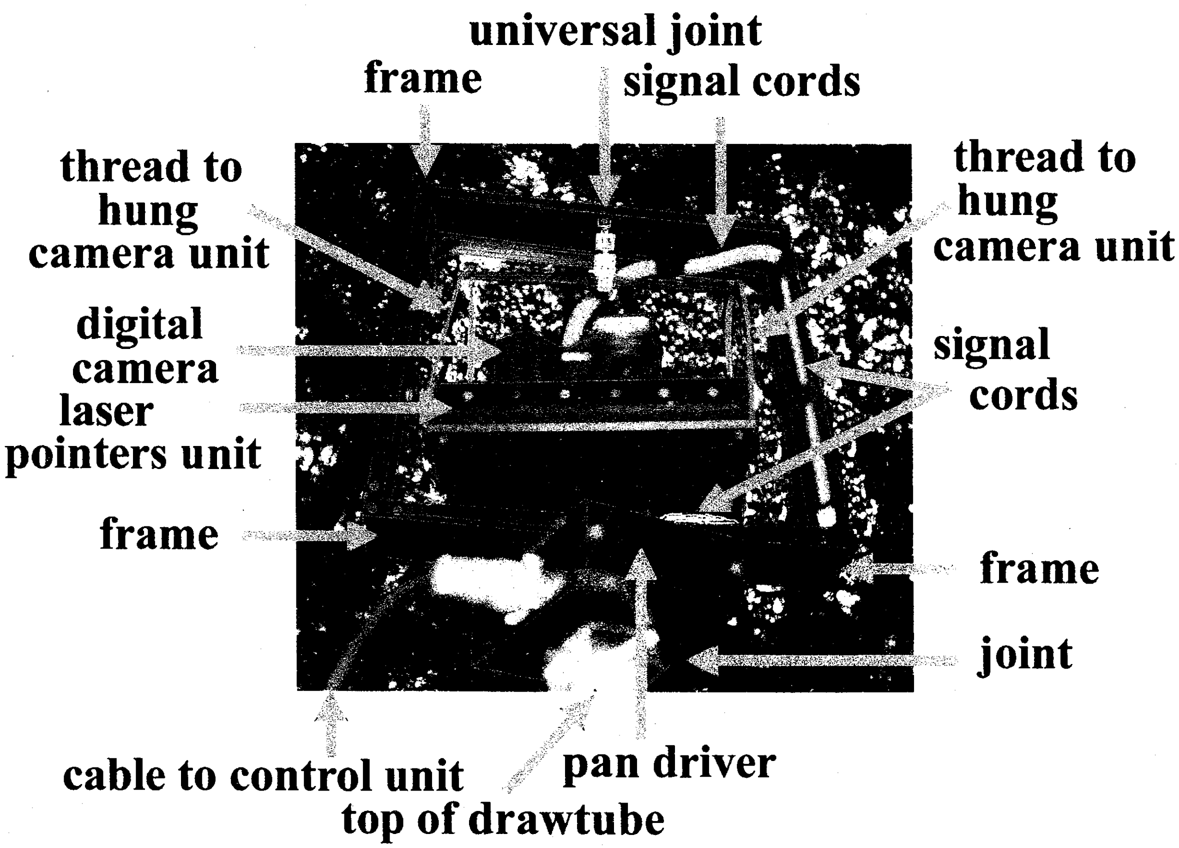

Fig.4 Details of self-leveling of camera unit

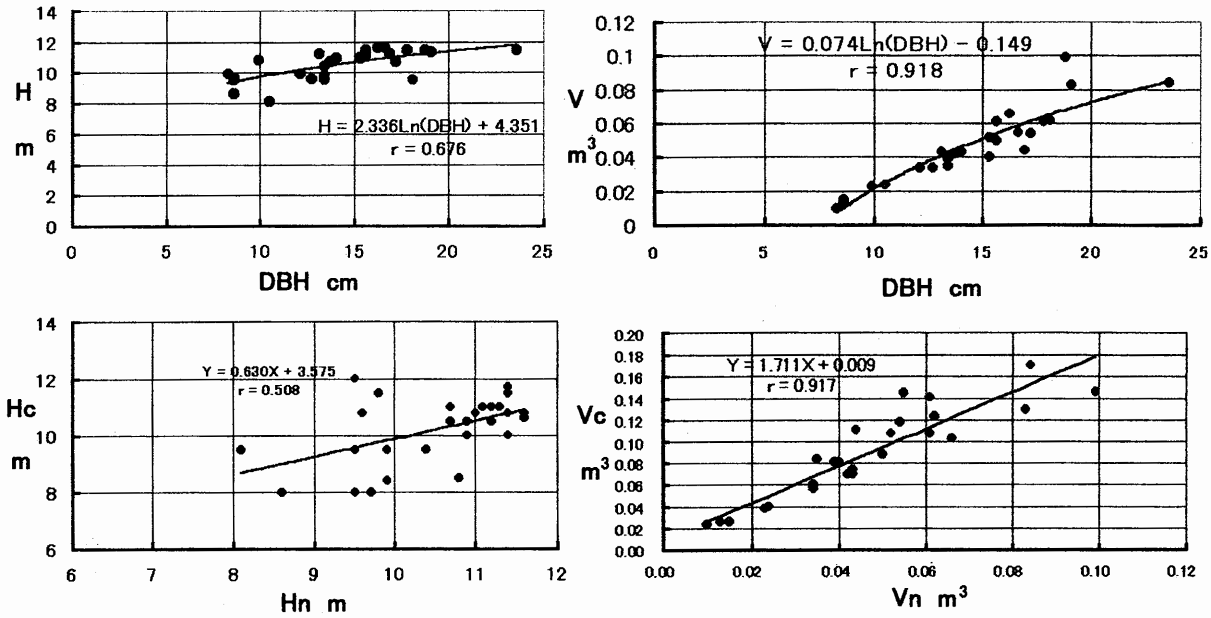

Fig.5 Two relationships between DBH ant tree height (H), trunk volume (V) of measurements and calculated values by the final improved system (above), and comparison of tree height and trunk volume by the system (Hn,Vn) and conventional way (Hc,Vc)(below)[2)]

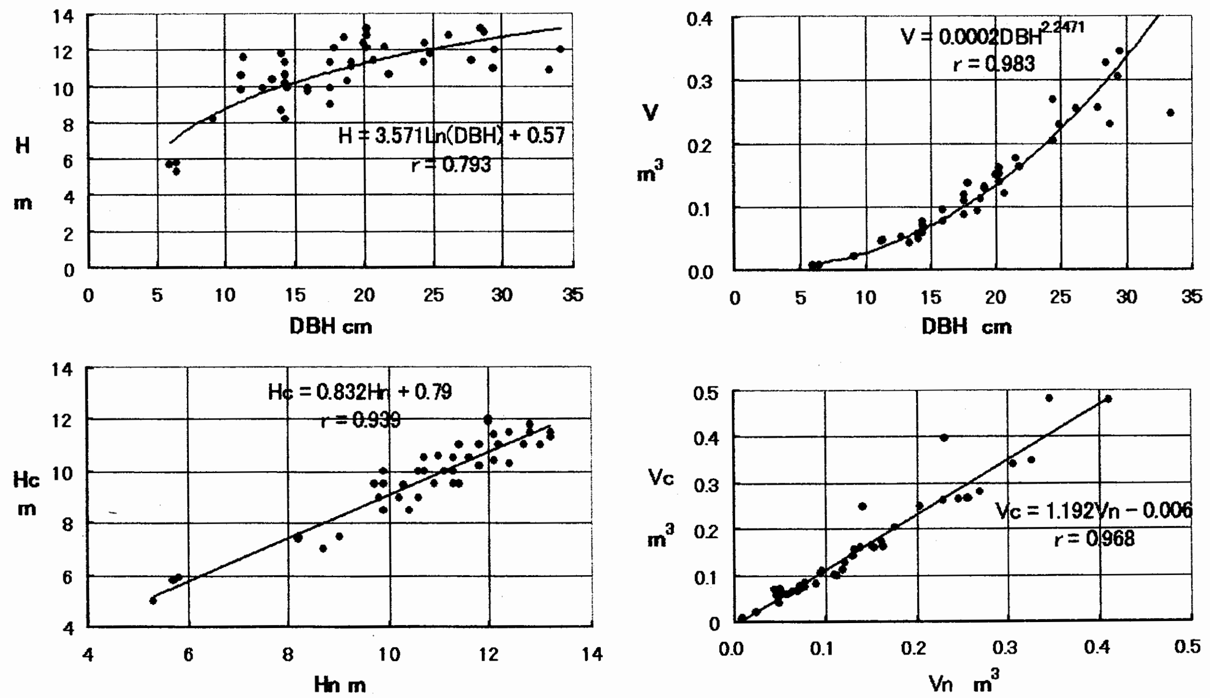

Fig.6 Two relationships between DBH ant tree height (H), trunk volume (V) of measurements and calculated values by the final improved system (above), and comparison of tree height and trunk volume by the system (Hn,Vn) and conventional way (Hc,Vc)(below)

3. Application test

Application tests of these developed and improved systems were done comparatively with the conventional ways at some plots in several stands of the mangrove forest in the river mouth of Fukido-gawa River in Ishigaki Island, the most southern part of Japan.

For conventional ways, a retractable ladder of 6 m length was prepared to climb a trunk. Diameter at each height with intervals of 1 or 2 m was measured by climbing a trunk and the distance from the highest position can be climbed to the tip of trunk was estimated by eyeballing with guide rod. Time was recorded separately as the time for moving and setting up the ladder and measuring time from start of climbing till completely getting off the ladder.

For this method, the poles were stood on the stabilizer and fixed with bolts in the shorten posture of all drawtubes, camera unit was fixed to the top of the thinnest drawtube, after that all connectors were connected. Each drawtube was pulled up stepwise and made a junction with next drawtube. We could read the scale of the fine surveyor's tape fixed zero to the side of camera as the height of camera. At a height, pan driver was adjusted to irradiate symmetrically laser red points to a target trunk and imagery was taken. If trunk and red points were too small in the monitor, the function of zoom up could be used properly. After taking all imageries of target trunks at same height, tube was pulled up to next height and same works were repeated. At the last phase, tree height was measured with the tape adjusting the height of camera to capture the tip trunk in the center of monitor. Time was recorded separately as the time for setting up this system, taking all imageries needed, measuring the height of target trees and setting off this system.

Diameter of a trunk at a height could be calculated from proportional relation between width of the trunk and distance of red laser points in the imagery. The volume of each trunk was calculated as total volume of all divided frustums and the tip cone.

4. Results and discussion

Time required for measurement per a tree was 4 minutes 38 seconds with conventional way and 4 minutes 26 seconds with this method. It was considered that the former was almost the limit but the latter could be reduced by experience[2]. In case of application test in this year, average time of the latter was slightly longer than the former. It is considered that the difference of time required for measurement results from stand conditions such as tree size, tree density and so on, and proficiency of the measurement crew. The improvement of safety and accuracy is more important than the shortening in time required.

The results of measurements by the first improved system were shown in Fig. 5[2]. And the results by the final improved system were shown in Fig. 6. Correlation coefficients of four relationships in Fig. 6 were clearly higher than them in Fig. 5.

In Fig. 5, measurements of tree height had scattered in wide range. And calculated values of trunk volume by conventional way were too much comparing with those values by this method. The reasons were probably eyeballing length of tip cone and tying a tape diagonally against trunk for measurement of the perimeter with insecure attitude on a ladder or trunk, and the works was an unaccustomed works for the crew of students. For the relationships between DBH and trunk volume (V) in Fig. 5 and 6, different regression equation were applied because of the difference between the ranges to be collected data. It could be evaluated that the accuracy of measurement was improved by this method.

By these improvements, operational safety and stability were advanced remarkably. And the accuracy of measurement also was raised because of the advancement in preserving the pole to support the camera upright. Although this method has a demerit that the number and weight of equipments increase, it is realized that cutting down trees and climbing up trunks are avoided. The matters are the most important merits from the points of view of the safety and minimizing the hardness of field works. It can be suggested that this method explains the possibilities to develop small scale remote sensing in the forest.

5. Device and improvement

In the field survey the weight of equipment becomes the most severe problem. Especially in mangrove forest the transportation of poles is hard, but the weight of about 50 kg must be accepted in consideration for its place, strength and shorten length during transportation. We divided it into two and brought them in the field.

Although the main improvement was completed in these serial studies, problems of making the system sturdier and higher are remained.

References

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