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Development of New Method for Field Survey of Stand Parameters on Mangrove Forest A Prototype and Application Test

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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 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 a tree 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 type of remote sensing in the forest. The usefulness should be increased with some devices and improvements. And it will become easier to collect data for stand parameters of mangrove forest combined to the satellite data.

. Introduction

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. Before measurement of DBH or tree height, we must make clear correlation between them and trunk volume and obtain regression equations among them. It is difficult to measure parameters on the form of trees than the crop. In mangrove forest it is more difficult 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 are to measure diameter at each height with intervals of some meter by climbing a tree 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 implement for measurement of a vertical angle to the top 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 top of tree can be penetrated many leaves and branches.

The purpose of this study was to develop an efficient method without hardness and riskiness introducing a remote sensing point of view into the field survey in mangrove forest. The data of stand parameters is 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.

. Methodology and a prototype

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 top of trunk by looking up the top and comparing with a guide rod at the position. The former was read for taking picture of trunk at a height and the latter for measuring the height of camera where the top of trunk can be seen in the center of viewfinder, 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 cone of the top.

In this study, 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.

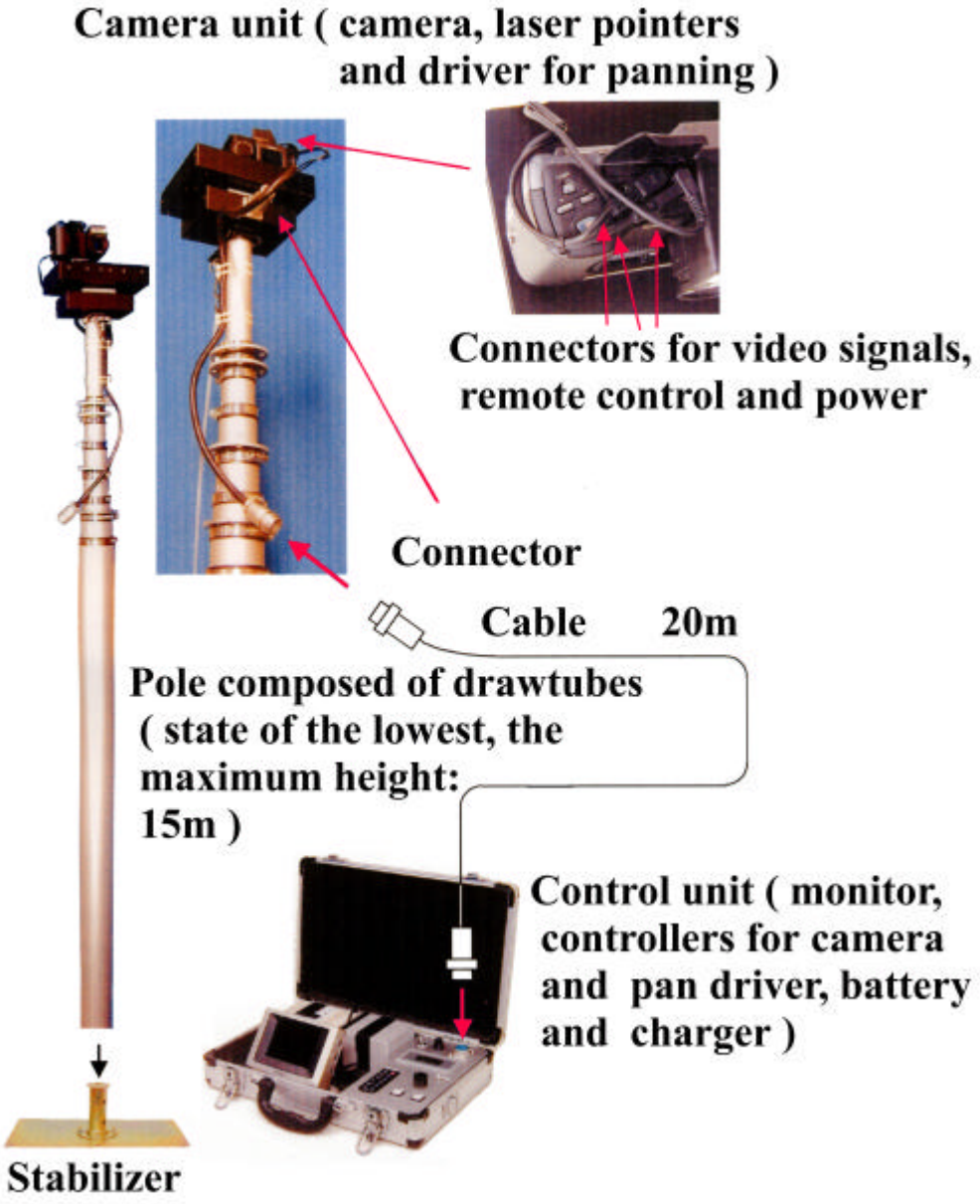

Fig. 1 Composition and connection on developed new method for measurement of stand parameters in mangrove forest

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 a walk is hard as mentioned above. As a solution for this problem, we applied some 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 a scale of a length, the diameter at a height of camera supported by the pole can be calculated with this length 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 in Fig. 1. And the details of the camera unit and control unit were shown in Fig. 2.

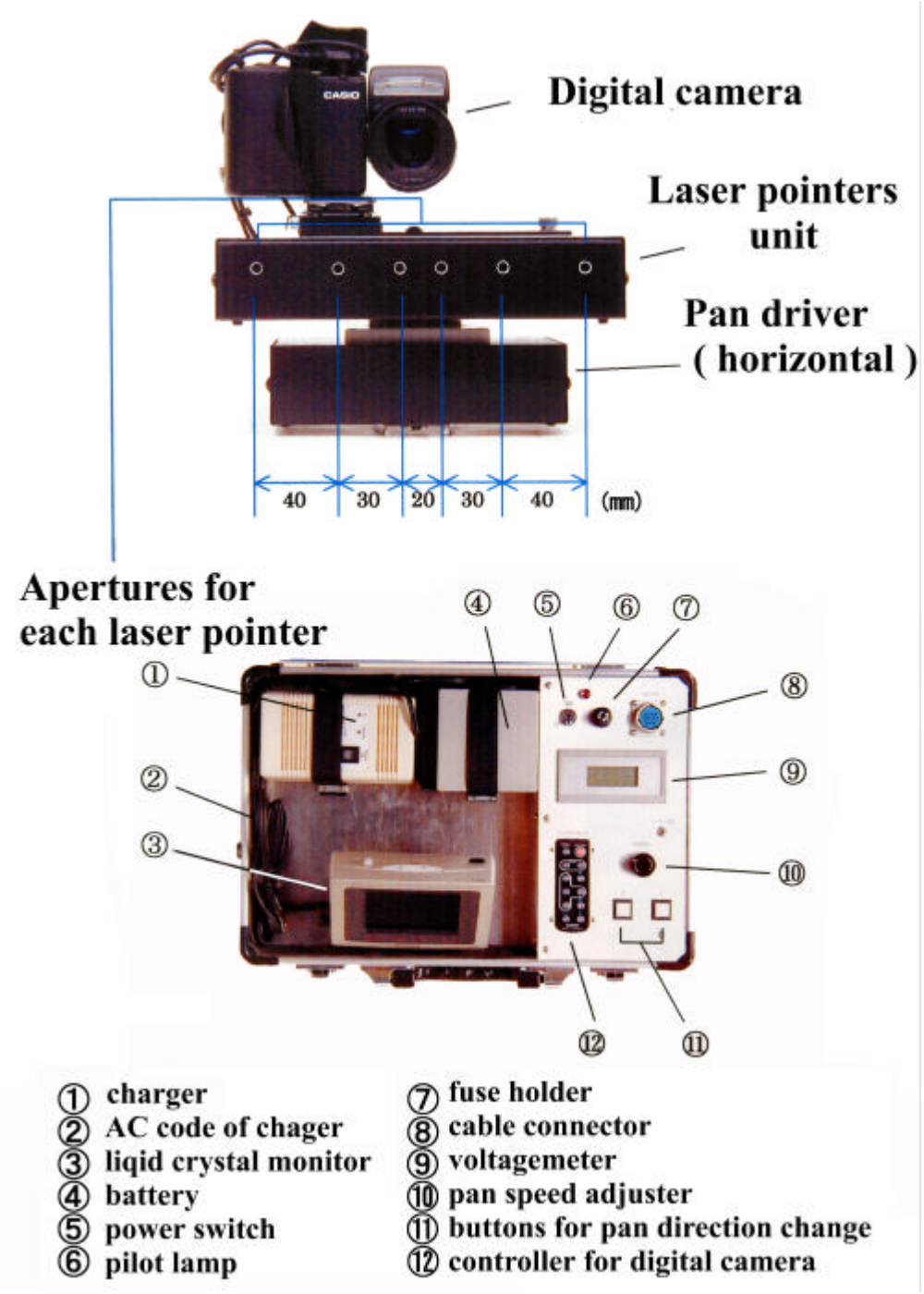

Fig. 2 Details of camera unit and control unit

Fig.3 Comparison of field survey situation between conventional ways and developed new method

- **Actual application**

The length of pole was designed as 15m on the assumption that the maximum height of mangrove tree is 15m in Okinawa. This pole was composed with 8 drawtubes to have different diameter step by step like as a fishing rod. For holding the pole straight, a pipe of 70cm length is connected to the stabilizer with bolts as a pile and the pole is stayed from adequate heights. The situation of operation in mangrove forest was shown comparatively with the conventional ways in Fig. 3.

The pole is stood on the stabilizer and fixed with bolts in the shorten posture of all drawtubes, camera unit is fixed to the top of the thinnest drawtube, after that all connectors are connected. Each drawtube is pulled up stepwise and made a junction with next drawtube. We can read the height of camera at the surface of sediment with the fine surveyor's tape fixed zero to the side of camera. At a height, pan driver is adjusted to irradiate symmetrically laser red points to a target trunk and a imagery is taken. If trunk and red points are too small in the monitor, the function of zoom up can be used properly. After taking all imageries of trunks at same height, tube is pulled up to next height and same works are repeated. At the last phase, tree height is measured with the tape adjusting the height of camera to capture the top of trunk in the center of monitor.

Diameter of a trunk at a height can be calculated from proportional relation between width of the trunk and distance of red laser points on the imagery. The volume of each trunk is calculated as total volume of all divided frustums and a top cone of the trunk.

- **Application test**

Application test of this developed new method was done comparatively with the conventional ways in a mangrove forest in the river mouth of Fukido-gawa River in Ishigaki Island. A sample plot of 25m by 25m was set for this test.

Fig. 4 Laser red points on a trunk and the top of a crown

At first complete enumeration was done by the conventional ways in this plot. For this survey a retractable ladder of 6m length was prepared for climbing trunk. Diameter at each height with intervals of 1 or 2m was measured by climbing a trunk and the distance from the highest position can be climbed to the top of trunk was estimated by looking up and comparing with a guide rod. Time was recorded separately as the time for moving and setting up ladder and measuring time from start of climbing and measuring till completely climbing down the ladder.

After that this developed new method was applied for similar measurement in same plot. But the measurement was not completed yet. The measurement on about 75% of tree number was remained because it was easy to measure for trees around the pole but many trees were remained in complex position behind measured trees. This problem arises in the case to compare these two methods. As such problem does not arise when only new method is applied, it is not severe problem as development of new method. We will complete measurement for all trees in this plot near future.

. **Results and discussion**

From result of the conventional ways, total number of trees of *Bruguiera gymnorrhize* was 60, average of DBH was 14.2cm, average of tree height was 9.7m and average of trunk volume was 0.0883m^3. Total number of trees of *Rhizophora stylosa* was 17, average of DBH was 14.1cm, average of tree height was 10.3m and average of trunk volume was 0.0776m^3.

Average of time for moving and setting up ladder was 245 seconds, it for measurement was 256 per one tree. Although it took 681 seconds for all action per one tree in the beginning of working, it decreased to 361 seconds per one tree with familiarization in the end of working.

From the result of the developed new method, only the time for working was examined because the difference between two methods was clear and numerical data for tree height, DBH and trunk volume were not enough. The time of working included moving, preparing and measuring time per one tree was 349 seconds in the beginning of working.

361 seconds by the conventional ways and 349 seconds by the developed new method were considered almost similar. But the former was measured in the end of working and the latter was measured in the beginning of working. Although the decrease of the former can not be expected, the decrease of the latter can be done enough. Furthermore it is considered that the former value increase rapidly than the latter value in higher mangrove forest. It is certain that the hardness and riskiness of working by the conventional ways also rapidly increase under such condition.

As it can be successfully shown that this prototype has large efficiencies, we will make efforts at improvement of this method.

It does not become clear yet that this method brings increasing accuracy of measurement. But we can show the large variance of measurement values by the conventional ways. The relationship between DBH and tree height was shown

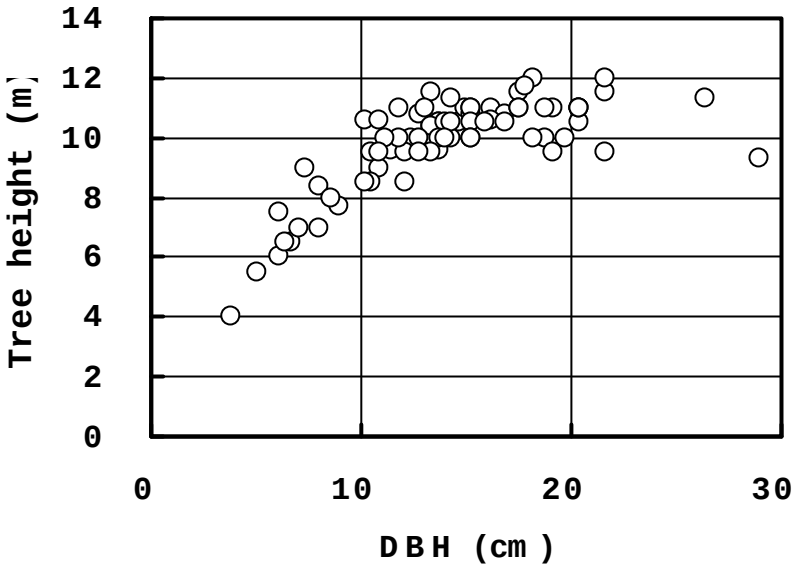

Fig. 5 Relationship between DBH and tree height in the data by the conventional ways

in. Fig. 5. It is considered that the large variance of tree height can be attributed to the eye measurement of distance from the highest climbed position to the top of trunk. We are certain that the way to measure tree height by the new method is better than the conventional ways.

6. Device and improvement

In the field survey the weight of pole is the most severe problem. Especially in mangrove forest the transportation of the pole is hard, but the weight of about 40kg 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.

It became hard to pull up the pole for measuring diameter of trunk and tree height at higher position because the weight of pole increased step by step. To this problem we will introduce a handle reel to roll-up fine plow steel for pulling up jointed part of drawtubes through a small fixed pulley and driving pulley. By this device pulling up of pole becomes stable.

To hold the pole straight a small level is set on the box laid laser pointers in and the level is monitored through a small CCD camera. We improve the fixing of laser pointers to be kept parallel. This is basically important problem of the developed new method.

The advancement can be expected in accuracy of measurement and manipulation of this new method by these devices and improvements.