#7545 DEVELOPMENT OF CANOPY MAPPING SYSTEM OF ASIAN PEARS (PYRUS PYRIFOLIA NAKA) USING TERRESTRIAL LASER SCANNING

Jaehwan Lee[1]*, Eiji Morimoto[1], Kazuyoshi Nonami[1], Ichizen Matumura[1], So Sato[2], Mana Ikebe[2]
[1]United Graduate School of Agricultural Sciences, Tottori University, Japan. [2]Faculty of Agriculture, Tottori University, Japan, D19A1106B@edu.tottori-u.ac.jp

ABSTRACT

Bud thinning and Pruning in Asian pears (Pyrus pyrifolia Naka) is necessary to ensure the quality and number of fruits but is time-consuming and heavily dependent on work experience and time availability. The objectives of this research were 1) establishing a method for measuring point cloud data of pear trees, 2) to validate the number of fruits prediction based on point cloud data analysis. Point cloud data of pruning of the orchard were measured by using a Terrestrial Laser Scanner (TLS; Topcon GLS-2000). The number of measured point cloud points is 18,682,993. Then, to measure the length of the branches, tree data were extracted from the point cloud data, and the predicted number of fruits was verified based on 8 pears/m of each branch. For example, a tree branch with an area of 24 m² (number of points 31,975) has a total length of 22.9 m, multiplied by 8 to calculate the estimated number of fruits from 3D scanning data. The predicted number of fruits was 183 and the actual number of fruits was 164. That means it has 19 fewer fruits than the theoretical number of fruits. So, the measured number of fruits/m² was an average of 6.8, and the Predicted number of fruits/m² was average at 7.6. The absolute error of the two results was 0.8/m².

Keywords: orchard management, Asian pears, point cloud data, remote sensing, fruit yield prediction, bud thinning, pruning

INTRODUCTION

According to the Japanese Census of Agriculture and Forestry in 2015, 74% (i.e. 24,511 people) of farmers in Tottori Prefecture are over 60 years old (Static Agriculture Census, 2015). Recent cultivation trends have decreased the area of Japanese pears due to the aging of producers, lack of labor, and aging of pear trees. This may be due to reduced production, lower prices, reduced employment due to aging, and reduced agricultural land. Japanese pear is more difficult to cultivate than other fruit trees, and intensive farming is necessary (Yamada, 1983). But cultivation techniques take decades to acquire with tacit knowledge, and most of the work relies on the sensory experience of workers (Suenaga, 2009). As a result, orchard data is becoming important for both skilled and unskilled individuals. For example, research on visualization of agricultural records using telemetry and sensors is being conducted on rice crops. Morimoto et al. (2017) developed a smart rice transplanter to measure topsoil depth and soil fertility values. Pruning and buds thinning are the ones that have a large impact on the yield and quality of pear crops. Because, the yields of pear were closely correlated between pear trees biomass parameters such as canopy area and the total length of LAI (Yoshida et al., 2006). So, a study on the characterization of various pruning methods of apple trees for the preparation of pruning manual for beginners was also conducted (Asada, 2006). Bud thinning is the process of identifying of buds which are thought to be an abnormality (twin flowers, etc.) or poor growth, and removing them from the tree. Japanese pears are produced on the basis of 12,000 pears per 10a, and it is said that it is best to have 8 pears per 1m of the branch. The problem,

however, is the time-consuming work of walking through the orchard and checking the unusual buds by the workers. The know-how of horticulture of fruit is the accumulation of experience gained from decades of work experience, and the hurdles of technological succession to new farmers. However, the research to prove the correlation such as the quality according to the work has been carried out, but the research on the recording and utilization of the work contents of the expert has not proceeded. Therefore, in this research, Tree data measurement with 3D scanner data was developed. The objectives of this research were to establish methods for collecting orchard point cloud data and analyze tree data.

MATERIALS AND METHODS

Terrestrial Laser Scanner (TLS) uses a tripod-mounted, Light Detection and Ranging (LiDAR) to create a high-resolution 3D point cloud of objects. LiDAR technology is one option to collect data about the canopy geometry of plants in tree crops and it is a method that can measure large areas such as forests and orchards in a short time (Karp et al., 2017; Liang et al., 2016). In this study, the point cloud data of the orchard was measured using a 3D scanner (Topcon's GLS - 2000) In March 2018. There is a total of four measuring points, and the number of measured point cloud points is 18,682,993 (Fig. 1). The point cloud data is used to record the pruning of the orchard. In this study, was used the point cloud data to measure the length of branches.

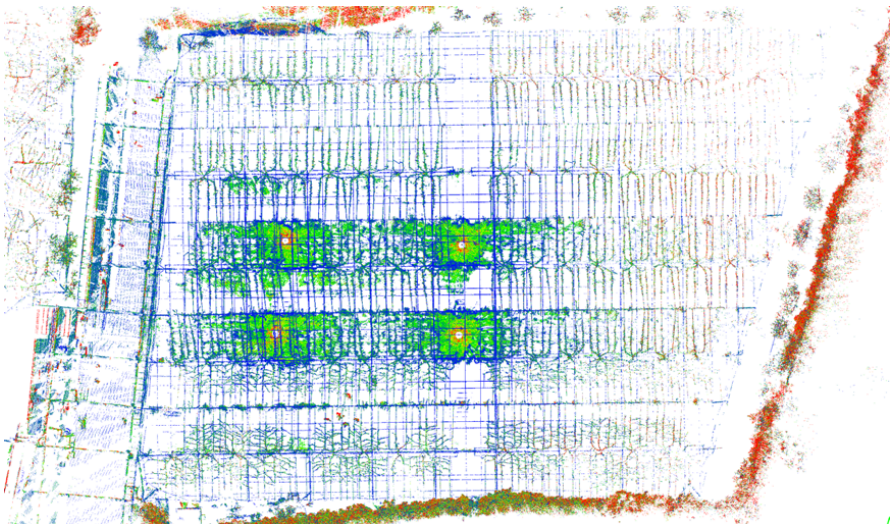

Figure 1. Point cloud data of orchard.

Using a tripod, a common measurement method for Asian pear orchard measurements, the data measurement time per measurement point is about 30 minutes. So, to simplify the installation of the TLS, a new type of fixing device Ground-station was made (Fig. 2). The Ground-station was pinned 30 mm below the ground of the measurement point. The Ground-station is divided into a fixed iron plate at the bottom and an upper part, which is the instrument fixture. The upper part can be moved, and the installation height of the 3D TLS is 100 mm from the ground. In March 2018, the instrumentation was started using a Ground-station and the scanning time was 10 minutes. Instrument points were all measured before scanning by Topcon's LN - 100. Since the measurement time was fasted by 1/3 than the tripod fix method. As a result, high-density point cloud data could be obtained in a shorter time.

(a) Tripod-mounted (b) Ground-station-mounted

Figure 2. 3D scanner mount method.

RESULTS AND DISCUSSION

The survey methods were obtained from the orchard in August 2018 with the number of fruits for each tree. Also, the point cloud data was obtained in March 2018 after pruning to measure the length of tree branches using the point cloud data. Sample tree data were extracted to verify point cloud data measured in the orchard. It is assumed that 8 fruits are produced per 1m, which is the standard cultivation method of Japanese pears. After measuring the length of tree branches using point cloud data, the optimum number of fruits was calculated and compared with the total number of actual productions. Estimates of the number of fruits analyzed the absolute error between the length of each tree branch and actual the number of fruits. The result was as follows. For example, the total length of tree A branch was 22.9m and the total length was multiplied by 8 to calculate the predicted number of fruits (Fig. 3). As a result, Tree A produced 164 pears in 2018. And, estimates of the pear number of fruits based on the length of the branches were 183 and the area occupied by trees is 24 m². So, the measured number of fruits/m² was average 6.8, and the Predicted number of fruits/m² was average 7.6. The absolute error of the two results was 0.8/m² (Table 1).

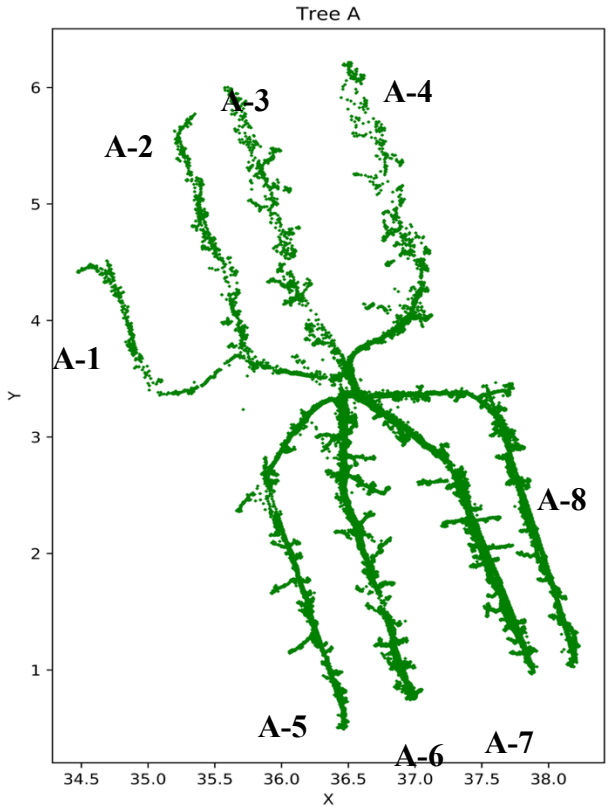

Figure 3. Length measuring of the branch of sample tree by point cloud data.

Table 1. Result of predicted number of fruits.

	Tree A	Tree B	Tree C	Tree D
Area (m²)	24.0	21.0	21.0	15.0
Branch length (m)	22.9	26.9	21.9	21.0
Predicted fruits	183.1	215.3	174.9	157.7
Measured fruits	164.0	218.0	192.0	124.0
Absolute error	19.1	2.7	17.1	33.7
Predicted fruits/m²	7.6	10.3	8.3	10.5
Measured fruits/m²	6.8	10.4	9.1	8.3

*Absolute error: (Predicted fruits - Measured yield)

As a result, the comparison between the number of fruits prediction data and the actual number of fruits was in the range of an average of 20.65. And, the number of fruits per unit area could be estimated through analysis of point cloud data. And, the average of the measured and predicted number of fruits was 8.7 number of fruits /m² and 9.4 number of fruits /m².

CONCLUSIONS

In this paper, the CMS of Asian pears for estimating the number of fruits during Bud thinning and Pruning operations using point cloud data was proposed. The results of this study can be used to determine the number of fruits during thinning operations conducted from December to April in Asian pear horticulture. We collected 18,682,993 points cloud data containing Asian pear tree shapes using TLS. The experimental results showed a similar number of fruits/m² when compared to different each tree data, but it was confirmed that the measured number of fruits/m² was less than the predicted number of fruits/m². Thus, the predicted number of fruits/m² may not be sufficient for practical application. In actual Pruning, however, the worker does not know the total length of branches that need to be removed, and the total length of branches remaining. The number of fruits by the length of the branch can, thus, only be determined on the basis of worker experience with canopy map. If this information can be mapped, it may be possible to adjust the number of flower buds to the theoretical number at the time for flower thinning in the next season. In the future, the producer can probably make next year's schedule for pruning and buds thinning by using accumulated data over the years. Therefore, we will conduct research to confirm the relationship between the canopy area and the number of pears to be harvested. From the above results, the proposed CMS proposed a method to efficiently measure parameters necessary for the management and monitoring of orchards.

REFERENCES

Asada T. 2006. A study of differentially located apple tree spurs. Bulletin of the Faculty of Agriculture and Life Science-Hirosaki University (Japan).

Karp FHS, et al. 2017. Accuracy assessment of a mobile terrestrial laser scanner for tree crops. Advances in Animal Biosciences 8(2): 178-182.

Liang X, et al. 2016. Terrestrial laser scanning in forest inventories. ISPRS Journal of Photogrammetry and Remote Sensing 115: 63-77.

Morimoto E, Hayashi K. 2017. Design of smart agriculture Japan model. Advances in Animal Biosciences 8(2): 713-717.

Static Agriculture Census, Ministry of Agriculture and Forestry and Fisheries. 2015.

Suenaga S. 2009. Agriculture, forestry and fisheries and knowledge management. Agricultural management research 46(4): 8-16.

Yamada. 1983. Technological Change and Farm Development of Pear Production: A Case Study of Pear Farming in Chiba Prefecture 32: 81-91.

Yoshida A, et al. 2006. Effects of various training systems on canopy development, yield and fruit quality in young filler trees of Japanese pear [Pyrus pyrifolia] Gold Nijisseiki. Horticultural Research (Japan).