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Lidar Utilization for Real-Time Confirmation of the Growth Status of *Sorghum Bicolor* in Field

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[Introduction]
Recently, the agricultural system is expanding into the 6th industrial era. All over the World, the core technologies of the 4th industrial revolution are being grafted to make automated agricultural works with unmanned and intelligent technologies. In this automation, construction and research of phenomics facilities that convert non-destructive plant phenotypic information into DB based on images are being actively conducted. Although the use of phenomics and canopy systems is increasing for the measurement of growth information on open field crops, which account for 85.6% of the total agricultural land area, however it is difficult to apply to domestic field crops due to the high cost of equipment and operation. In particular, it is urgent to establish a growth information-based technology optimized for measuring the growth information of field crops. To measure the growth status, we introduced the real-time growth measurement technology using LiDAR for *S. bicolor*.

[Materials and Methods]
LiDAR was measured at a height of 2-3 m to obtain the object information of *S. bicolor*. For the measurement, *S. bicolor* was labeled individually, and then LiDAR imaging and measurements were performed at weekly basis. LiDAR image data was subjected to image pre-processing such as visualization of point cloud data and noise removal. The pre-processed data were labeled for stems, leaves, and ears, followed by learning and segmentation. Various deep learning models (PointNet, PointNet++, Dynamic Graph CNN, PointCNN, ShellNet, RIConv) were used to compare the performance of each model. For the deep learning model, actual measurement information (5,880 pieces) and LiDAR image data (360GB) were used.

[Results and Discussion]
The results of measuring plant length, culm length, stem diameter, ear length, and ear width of *S. bicolor* with image data are as follows. The average error of 87% of the plant length was 1.9 cm. The culm length had an average error rate of 2.04 cm with an accuracy of 84%. The stem diameter had an accuracy of 81% and an average error rate of 1.93 mm. The ear length had an accuracy of 86% and an average error rate of 66 mm. The ear width had an accuracy of 89% and an average error rate of 6.86 mm. The average measurement took 2.7 hours for three people, but it took about 47 minutes unmanned when acquiring image data, so the possibility was confirmed as a means to replace the growth survey with minimal time requirement.

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